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EDITORIAL

GOATS AND RINDERPEST

THE prevalence of rinderpest, more than any other single cause, prevented the late Veterinary Department from launching upon any extensive scheme for the development of animal husbandry. On the one hand all the time and all the energy of the Department had to be directed to the one purpose of eradicating rinderpest : on the other the knowledge that at any time an epidemic of rinderpest might kill off his herd did not encourage the farmer to undertake the improvement of his live-stock. Happily the efforts of that Department were successful, and in the year 1935 it was able to report that Ceylon was free from rinderpest, and that the disease could re-appear only as a result of introduction from abroad. Such introduction through the medium of cattle was effectively prevented by allowing the import of cattle from Asiatic and African ports only through the port of Kayts under the strictest conditions of quarantine in an island which has no bridge connexion with the mainland. It is proposed to permit import of cattle for breeding purposes only through Colombo from the beginning of next year ; but quarantine regulations which are quite adequate to prevent the introduction of rinderpest will be enforced.

It has, however, become necessary to sound a note of alarm. The administration report of the Madras Civil Veterinary Department for the year 1935-36 contains the statement that " it is thought that the loss amongst sheep and goats in outbreaks of rinderpest is considerable." The Annual Report of the Sind Veterinary Department for the preceding year records that in one outbreak of rinderpest in Hyderabad district 200 sheep and goats were affected of which 50 died. In June 1935 the import of goats from Siam was prohibited by the

Government of the Straits Settlements on account of rinderpest and in November of that year the same Government prohibited the import of goats from India on account of a contagious disease which resembled rinderpest. It follows from these experiences of other countries that so long as we continue to import goats from countries in which rinderpest is enzootic we take the risk of having our cattle re-infected, which will be a calamity of the first magnitude from the point of view of the still scarcely renascent animal husbandry industry.

Nothing short of absolute security can satisfy us, and that security can be ensured only by the prohibition of all imports of goats except a few animals of pedigree stock for purposes of breeding, and by the adherence in such cases to the strictest rules of quarantine, followed by a long period of observation after release from quarantine. Ordinary quarantine only during the period of incubation of the disease is not enough because observations made by the Straits Veterinary Department show that : " A consignment of infected, but somewhat resistant, imported animals could be responsible for an outbreak of rinderpest in other cattle to which they had come in contact some considerable time after the infected animals had been removed from the original source of the disease. In the infected lot the disease could pass gradually and almost unnoticed from animal to animal, and the larger the number of animals in the consignment, the larger could be the period over which the infection might exist."

The public, however, wants goats' flesh, and Ceylon cannot supply the demand at present. Therefore the policy of Government should be directed towards the extension of goat rearing in the villages up to the point where local supplies can meet the demand steadily, goat rearing being stimulated by the definite promise that imports for slaughter will be prohibited as soon as local supplies become sufficient, and, in the meantime to provide for the removal of all goats and sheep imported for slaughter from the harbour direct to a detention camp attached to the slaughter house either by water, where water transport is available, or in closed motor lorries.

Some uneasiness has been expressed regarding the probable effect of goat rearing on a large scale. It is suggested that it will lead to the progressive denudation and the eventual desiccation and the reduction to desert conditions of land in areas of scanty or badly distributed rainfall. We propose to discuss this aspect of the question in another number of this journal.

THE PROPAGATION OF THE MANGO IN JAFFNA—II

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IN the first part of this article which appeared in the February number of *The Tropical Agriculturist* for this year, an account was given of a method of budding the mango, found to be most successful at the Farm School, Jaffna, where work on this fruit tree is being pursued. The present paper deals with a few other details on the subject of the propagation of the mango, based on the results obtained at the Farm School.

PREPARATION OF BUDDING TAPE

It is essential that in budding operations, a tape which is uniformly and suitably impregnated with a wax preparation should be used so that it should remain adherent and act as a sufficient protection when wrapped around the budded patch until the bud and stock have united. When it becomes necessary to expose the bud after union has taken place and to remove the tape, it should when unwrapped come away without difficulty. Several methods of preparing waxed tape have been described by horticulturists but the following has proved most satisfactory and, in particular, ensures an even distribution of the wax over the tape.

A smooth, round stick of about 1 inch in diameter and about 2 feet in length is used, and on it is rolled a strip of longcloth about 4 feet in length and about 6 to 9 inches in width, the cloth being held stretched as it is wound over the middle of

the stick. The wax to be applied is prepared according to the following proportions of the ingredients :—

Resin (crushed)	2 lb.
Beeswax	2 lb.
Tallow	1 lb.

The resin is first placed in a utensil and carefully heated over a slow fire. The beeswax is then added and, when it has melted, the tallow is put in, the contents being stirred continuously. When the tallow has dissolved and all the ingredients have mixed well, the liquid is poured into a tin, allowed to cool and harden for storage and use as required.

In the preparation of the waxed cloth, a small quantity of the solid wax is removed and melted. By dipping a brush or a small stick into the liquid, the outer surface of the roll is smeared over with a small quantity of it. The roll is then held using its two free ends as handles horizontally over a charcoal fire which is kept aglow by blowing through a bamboo or tin tube and, by slowly revolving the roll, the wax is gradually allowed to penetrate the inner layers of the cloth. When greater protection is needed to the budded part, as during the wet season, a somewhat heavier coating of the wax is given. If it is found that the coating of wax is too thick a second, but shorter, strip of cloth is wound over the first and by holding the roll again over the fire the excess wax is allowed to work its way into and be absorbed by the outer roll. It is possible, however, with a little experience to ensure the correct degree of impregnation with the first application of the wax.

The cloth is now unrolled and cut into ribbons of about $\frac{3}{4}$ to 1 inch wide. These strips are then rolled into separate bandages and kept in airtight tins for use when required.

POTTING

When the shoot growing from the bud used on the stock has reached a height of about 12 inches, which usually takes about three months as the growth period of a flush, the plant is ready for transplanting to a site which should be somewhat near the nursery or for potting if it is intended for sale and, therefore, for transport to more distant sites. During a year there are about three or four flushes, so that a budded plant should reach

a height of about three feet at the end of that time. The beds containing the budded plants are judiciously watered and periodically stirred to keep the soil in good tilth. All suckers from the stock portion of the budded plant should be removed as soon as they are observed.

Before potting, the tap root of the budded plant is pruned *in situ*. This is done by scooping out the soil about six inches away from the base of each plant towards the tap root which is then severed at a distance of about 4 to 6 inches from its apex, so that its length is not more than about 9 inches. The soil is then filled in and the plants are, again, regularly watered. On the red limestone loams of Jaffna it is found necessary to cease watering about a week before lifting the plants, so that they can be easily removed with a ball of earth adhering to their roots. At the end of about three weeks, the plants are carefully lifted each with its ball of earth and transplanted or potted as necessary.

In the preparation of pots, plain zinc sheets are used at the Farm School. These are cut into sections of about 12 to 14 inches, each of which is rolled and closed with dove-tailed joints into a cylinder with a diameter of about 4 inches. The cylinder is held together by being fastened both at the top and bottom by coir string. It is then allowed to stand on the ground and a small quantity of the red loam placed inside. This is rammed in with a pole so that it becomes compacted at the base of the cylinder to a depth of about $2\frac{1}{2}$ inches and, when the cylinder is lifted, the soil remains firm and acts as a porous bottom.

Zinc sheet pots are used in preference to any others because they are readily available and are suitable for transport. They are, moreover, not destroyed by termites and can also be easily removed when transplanting is carried out by untying the strings fastened around each cylinder which is then held in position by the hands while it is placed in the hole. The soil around is next filled in and the loosened cylinder can be gently drawn out. The price of zinc sheets has recently been increased and at the present time the cost of a piece of zinc sheet for making a pot is about 12 cents.

When each plant is removed from the nursery bed for potting, it is carefully pushed down the zinc sheet pot, removing any excess soil around so that the plant can be gradually fitted into the pot. More soil is added as necessary and firmed down making its level about ½ inch below the top edge of the cylinder. The plants are then watered and kept under shade for about a fortnight, after which period they should be ready for despatch.

It has been found that those plants which after being budded have their tap roots pruned and are then transplanted elsewhere bear earlier than those which are budded *in situ*. Transplanting should be done when there is no active flush on the young budded plants, but if present, it should be pruned before transplanting.

STOCKS

At present no precise data are available relating to the stocks suitable for budding and grafting different varieties of the mango. Horticulturists in the Jaffna Peninsula use any type of mango seed which they can procure—usually collections of seed from local markets. At the Farm School it has been found so far that the *pulima* or sour types of *Mangifera indica* are most suitable as stocks. There are several types of these *pulima* mangoes which usually grow on the sandy soils of the Tenmaradchi and Pachchilaippali Divisions of the Jaffna District in a semi-wild condition. They are, generally, large and vigorous growing trees which bear profusely, but with small fruits that are sold in the village markets, mostly to the poorer classes. Plants which are budded or grafted on *pulima* stocks require less attention in regard to watering and manuring than those which have been propagated on the better local varieties of *Mangifera indica* such as the common Jaffna mango or *vellai colomban chembattan* and *pandi*.

Trials with different types of *Mangifera zeylanica*, known as *kartuma* in Tamil and *etamba* in Sinhalese, for stock purposes are in progress. The trees of this species are large but the fruits are even smaller than those of *pulima*. Seedlings of *kartuma* in the nurseries of the Farm School appear to be less hardy and less vigorous than those of any other type. They appear to thrive only when there is a large quantity of organic matter in the soil and, so far, have given little indication of

being suitable as stock plants for budding purposes, the budded plants being slow growing in comparison with those which are budded on *pulima* stocks.

Amongst the better varieties of *Mangifera indica*, the common Jaffna mango or *vellai colomban* has so far given promise of being as suitable as *pulima* from the point of view of growth in a stock plant, but the collection of seed in large quantities is more difficult and costly. It is yet too early to state what the effect of different varieties of stock plants is on the flavour of the fruit and the bearing capacity.

When the seed has been prepared as described in Part I of this article, it should be planted about 6 to 9 inches apart each way in well-prepared beds raised about 6 inches above the ground to permit free drainage. It has since been found that better results in germination are obtained when the seeds are planted shallow and covered over by an inch of soil than when planted 3 to 4 inches deep as previously reported. The beds should be covered over after planting with a layer of dried plaintain leaves and watered daily. Germination takes place in about 6 or 7 days if the seeds are fresh, the covering being then removed. After about 3 or 4 months when the seedlings are about 12 to 18 inches high, they are removed with a ball of earth and transplanted in the budding beds at about 16 to 18 inches apart each way, the beds being about three feet wide and of any convenient length. The plants are then budded as described in Part I of this article.

It is advisable that budwood should only be taken from fully bearing trees so that a proper estimate of their performance is known beforehand. As previously reported, the budwood should be selected from twigs of the current season's growth, which show a pale green colour and smooth surface, the flush being not less than a month old, as otherwise the tissues are too tender for a bud to be removed satisfactorily.

SELECTION OF BUDWOOD

In budding the mango, as with any other perennial crop which can be propagated vegetatively, it is most important that budwood should only be taken from selected parent trees. In the first instance, only varieties which are recognized from the point of view of quality of fruit should be chosen, but

they should also be satisfactory in other characteristics such as high yield and regular bearing. There are some varieties, *e.g.*, *mulgova* which though of good quality bear neither well nor consistently in Ceylon, and it is unprofitable to propagate such varieties extensively until good yielding strains have been found. The next step is the selection of the best type of tree available of the particular variety, for there are individual differences of quality, yield, etc. between trees of the same variety, these having been propagated indiscriminately in the past. Trees which are comparatively shy bearers or which do not yield consistently are of little value to the commercial grower although they may produce fruits of good quality.

The following are the chief factors on which the quality of the mango fruit is determined :—

1. Firm pulp
2. Absence of fibre
3. Good flavour
4. Attractive colour
5. Good storage
6. Large size
7. Small stone
8. Resistence to insect attack and disease organisms

Amongst the numerous varieties of mangoes, both foreign and local, cultivated in the Jaffna Peninsula only a few are for commercial purposes suitable for propagation and conform to a high standard of quality. The following is a list of the varieties which the writers consider to be superior, chiefly from the point of view of quality, amongst these so far grown in the Jaffna Peninsula :—

Size of Fruit	*Name of Variety*	
	Foreign	*Local*
Large	..*dilpassand* .. (Synonyms—*Bangalora*, *Collector* and *Tota-puri*)	..
Medium	.. —	..*karutha colomban ambalavi vellai colomban*
Small	..*Willard gundoo*	..*chembattan*

Even this list is considered to contain too many varieties for propagation on a commercial scale although to cater to individual tastes a number of varieties are needed. It should be the endeavour of every mango orchardist to confine his attention only to one or two of the best varieties to facilitate the marketing of fruits of uniform quality. The writers are of opinion that *dilpassand*, *karutha colomban* and *willard* representing varieties with large, medium and small size fruits, respectively, at present merit the chief place amongst those grown in the Jaffna Peninsula. A description of the more important varieties grown in the Peninsula is being prepared for publication in a later issue of this journal. Many of the varieties found in Ceylon do not, however, merit propagation but most mango orchardists in the Island, unfortunately, take a greater pride in endeavouring to grow a large number of different varieties than in having under cultivation a particular variety of the best flavour so that a large quantity of fruit of uniform quality can be marketed.

STUDIES ON CEYLON SOILS

IX. SOME FRUIT SOILS WITH PARTICULAR REFERENCE TO CITRUS SOILS

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WHERE the climatic conditions are suitable, fruits of the tree type are grown in Ceylon on a variety of soils both from the textural and chemical standpoints. This is best exemplified in the case of the mango which grows on a wide range of soils from sandy loams to heavy loams in texture, on the poor, acid, laterite and lateritic loams and gravels as well as on the alkaline, lime-rich loams. Citrus species are perhaps more selective in their soil requirements, but have again been grown in Ceylon on a number of different soil types. Thus the light sands and loams of the Puttalam and Marawila districts, the lateritic loams of the Uva and North-Western Provinces, the limestone-derived loams of the Jaffna and Nalanda series, the Pleistocene red earths of certain parts of the Southern Province, the heavy alluvial loams and even the hard gravelly soils of the Western Province have all been cultivated (though not in all cases to any extent) with citrus. The degree of success achieved has varied with the soil type, the calcareous soils, the medium and light loams and the lateritic loams having proved most satisfactory for the crop. A fairly deep, well-drained soil is however essential, irrespective of the type of soil. Other citrus-producing countries and states like California, Florida, S. Africa, the West Indies and Palestine bear out the experience of Ceylon in regard to the variable nature of citrus soils. In Florida

the citrus soils are sands or light loams; heavy manuring is required for successful cultivation. In South Africa and California citrus groves are planted on a wide range of soils from light sandy loams to heavy clays, but highest yields are obtained on the lighter and medium soil types. The West Indian citrus soils are heavy in texture and usually rich in plant food and organic matter. The best soils are deep, medium-textured loams, friable and well drained. In Palestine too (1) citrus is grown on soils ranging from sands to limestone-derived heavy loams similar to the Jaffna soils.

In this paper, the results of morphological and analytical studies of five soil profiles in citrus groves situated in different parts of the Island are described and compared. Three other profiles of soils considered suitable for citrus are also included. In previous communications (2, 3, 4, 5, 6) on the soil groups of Ceylon, profiles of typical citrus soils have been described. The general characteristics of these soil types will be referred to in the course of the paper.

The analytical methods adopted have been the same as for the previous studies. The determinations of total potash and phosphoric acid have, however, been omitted, as the data so obtained generally do not show any correlation with crop performance. The results are presented in two tables. Table I comprises the analytical data of citrus profiles at Mundel near Puttalam, Gokarella in the Kurunegalla district, Embilipitiya and Bibile. The two former groves are situated in districts extensively planted with coconut. In table II are shown the data of profiles from a grove at Maha Illupalama in the Anuradhapura district and from Minneriya, Minipe and Hambantota where citrus is grown in close proximity, if not actually on the profile site. The data were first discussed separately and then collectively.

TABLE I

	Mundel		Gokarella	Embilipitiya		Bibile	
	A %	C %	A %	A %	C %	A %	C %
MECHANICAL ANALYSIS							
Stones and gravel	nil	nil	2·0	4·7	3·1	2·7	4·6
Coarse sand	62·8	64·8	44·1	41·7	35·8	31·2	26·3
Fine sand	28·1	25·6	32·5	24·2	24·6	30·6	23·8
Silt	1·3	0·9	8·6	6·4	6·2	4·4	4·1
Clay	6·8	7·6	10·7	22·5	27·7	28·4	39·4
Loss by solution	0·4	0·6	0·5	1·0	0·4	2·5	2·7
Moisture	0·6	0·5	3·6	4·2	5·3	2·9	3·7
Texture index number	6·5	7·2	10·3	21·1	25·7	26·2	36·0
Soil type	Sand	Sand	Sandy loam	Loam	Loam	Loam	Heavy loam
CHEMICAL ANALYSIS							
Loss on ignition	1·27	1·08	3·62	4·76	4·69	6·77	7·36
Organic matter	1·07	0·71	1·56	1·69	0·85	2·63	1·14
Combined water	0·20	0·37	2·06	3·07	3·84	4·14	6·22
Carbon	0·62	0·41	0·907	0·980	0·49	1·53	0·66
Nitrogen	0·046	0·043	0·078	0·062	0·053	0·127	0·059
Carbon/nitrogen ratio	13·4	9·4	11·6	15·8	9·5	12·0	11·2
Reaction (pH)	7·1	6·8	7·1	6·7	7·0	6·4	6·6
Total exchangeable bases (m.e. per 100 gm. soil)	2·94	2·75	7·75	8·84	5·87	5·36	3·65
Exchangeable calcium	2·73	2·11	5·64	6·91	4·59	4·36	2·52
Lime requirement cwt. per acre	—	—	—	8·0	—	17·7	—
(CaO) percentage	—	—	—	0·036	—	0·079	—
CLAY ANALYSIS							
Loss on ignition	18·06		27·05	24·02		22·01	
Silica (SiO_2)	59·22		45·76	44·24		42·36	
Sesquioxides (R_2O_3)	37·93		49·58	52·15		55·15	
Alumina (Al_2O_3)	27·52		34·70	36·77		39·38	
Iron oxides (Fe_2O_3)	10·41		14·78	15·38		15·77	
SiO_2/Al_2O_3 (molecular)	3·63		2·23	2·04		1·82	
SiO_2/R_2O_3 (molecular)	2·93		1·75	1·61		1·45	
Soil type	Non-lateritic		Non-lateritic	Non-lateritic		Lateritic	

MUNDEL

Elevation	About 20 ft.
Climate	Rainfall 45 in. (approx.) ; temperature 81° F.
Geological origin ..	Marine sands ; possibly Pleistocene plateau deposits
Mode of formation ..	Transported ; if latter, residual
Drainage	Probably excessive
Topography ..	Flat
Vegetation	Natural : medium to low jungle ; cultivated : *Citrus* spp., mangoes, etc.

PROFILE

A. 0-9 in. ..	Fawn grey sand ; loose and friable ; single grain ; root development good.
C. 9 in.-> 10 ft. ..	Greyish sandy loam with mottlings of rust brown becoming larger with depth ; hard but fairly friable ; root development good.

Both A and C horizons are markedly sandy, the percentages of sand being no less than 90 per cent. in each. The organic matter and nitrogen contents, particularly the latter, are as to be expected in this soil type, poor. The A horizon is about neutral and the C horizon slightly acidic in reaction. The replaceable base contents are poor. Calcium constitutes by far the largest proportion of these bases. The soils are definitely of the non-lateritic type, to judge by the silica/alumina ratio of the clay fraction.

GOKARELLA

Elevation ..	350 ft.
Climate	Rainfall 70 in. (approx.) ; temperature 80°F.
Geological origin ..	Residual
Mode of formation ..	Probably Pleistocene plateau deposits
Drainage	Good, tending to be excessive
Topography ..	Undulating ; fairly steep in parts
Vegetation	*Citrus* spp., coconuts

PROFILE

A.	0-15 in.	.. Uniform brown sandy loam ; compact ; hard but friable ; irregular columnar; root growth good.
C.	15 in.-4 ft.	.. Gravelly loam ; abundance of ferruginous pea-stones in varying stages of decomposition ; quartz gravel also present ; matrix brown sandy loam as above.

It will be observed that the A horizon is a sandy loam and the B a gravelly loam, the gravel being of the ferruginous, pea-stone type. The former is poor in organic matter and nitrogen, but has a fair content of replaceable bases. It is about neutral in reaction, and on the basis of the silica/alumina ratio of the clay complex, of a non-lateritic nature. The gravelly sub-soil will somewhat tend to restrict root growth.

EMBILIPITIYA

Elevation	250 ft.
Climate	Rainfall 61 in. (approx.) ; temperature 80°F.
Geological origin ..	Pleistocene red earth deposits, and probably crystalline limestone.
Mode of formation ..	Transported, aeolian ; residual if latter
Drainage	Good
Topography ..	Flat
Vegetation	Natural : medium to high jungle ; cultivated : *Citrus* spp., plantains, cotton, food crops.

PROFILE

A.	0-6 in.	.. Chocolate brown loam ; small quantity of ironstone nodules ; fairly compact; hard but friable ; granular ; good root growth ; horizon boundary indistinct.
C.	6 in.-> 4 ft.	.. As above but of heavier texture, the latter increasing with depth.

The soils are loams, the texture becoming appreciably heavier with depth. Both horizons, particularly the lower, are poor in organic matter and nitrogen. The A layer is slightly acid in reaction, its lime requirement being less than 10 cwt. per acre. The C horizon is neutral in reaction. The A horizon has quite a fair supply of replaceable bases—in fact a good supply so far as Ceylon soils are concerned, but the B horizon is only fair in this respect. The soil is of the non-lateritic type.

BIBILE

Elevation ..	..	830 ft.
Climate ..	..	Rainfall 85 in. (approx.); temperature 80°F. (approx.)
Geological origin	..	Felsphatic gneiss
Mode of formation	..	Residual
Topography	..	Undulating; sample from level area
Drainage ..	..	Good
Vegetation ..	..	Natural: medium jungle; cultivated: *Citrus* spp.

PROFILE

A. 0-9 in.	..	Yellowish red loam; compact but friable; irregular columnar; root growth good; horizon boundary indistinct.
C. 9-> 30 in.	..	Deeper yellowish red loam.

This is a profile of the soil at the Bibile Citrus Experiment Station. The A horizon is a medium loam, while the B horizon is of heavier texture. The former has a fair supply of organic matter and nitrogen but the latter is poor in both. In reaction, both horizons are acid though not markedly so, the upper being slightly less acid than the lower. The exchangeable base content is fair in the A and poor in the C horizon. The soil is lateritic in nature. It has a lime requirement of 18 cwt. per acre.

TABLE II

	Maha Illupalama	Minneriya		Minipe		Hambantota
	A %	A %	C %	A %	C %	A %
MECHANICAL ANALYSIS						
Stones and gravel	7·9	20·8	21·4	5·6	9·8	nil
Coarse sand	28·6	32·3	33·1	40·5	31·4	36·3
Fine sand	29·2	40·2	37·7	41·0	33·7	28·8
Silt	5·1	5·7	6·0	3·1	6·2	4·1
Clay	30·7	16·9	18·6	13·0	25·3	27·0
Loss by solution	1·9	2·1	1·9	0·8	0·9	1·0
Moisture	4·5	2·8	2·7	1·6	2·5	2·8
Texture index number	28·1	16·1	17·5	12·5	23·3	25·0
Soil type	Heavy loam	Sandy loam	Sandy loam	Sandy loam	Loam	Loam
CHEMICAL ANALYSIS						
Loss on ignition	5·85	5·07	4·77	3·19	4·29	4·07
Organic matter	1·81	2·31	1·13	1·44	0·84	1·22
Combined water	4·04	2·76	3·64	1·75	3·45	2·85
Carbon	1·06	1·34	0·66	0·84	0·49	0·71
Nitrogen	0·110	0·099	0·049	0·081	0·063	0·048
Carbon/nitrogen ratio	9·6	13·6	13·5	10·4	7·8	14·7
Reaction (pH)	7·0	6·8	7·3	6·4	6·6	7·5
Total exchangeable bases (m.e. per 100 gm. soil)	10·35	7·89	7·17	4·58	5·91	7·52
Exchangeable calcium	8·41	4·93	4·70	3·79	3·96	5·30
Lime requirement cwt. per acre	—	13·6	—	11·4	—	—
(CaO) percentage	—	0·061	—	0·052	—	—
CLAY ANALYSIS						
Loss on ignition	23·21	23·64		23·83		21·23
Silica (SiO_2)	43·52	45·36		42·98		40·50
Sesquioxides (R_2O_3)	52·01	51·45		53·10		53·03
Alumina (Al_2O_3)	34·24	35·48		33·09		32·27
Iron oxides (Fe_2O_3)	17·77	15·97		20·01		20·76
SiO_2/Al_2O_3 (molecular)	2·15	2·17		2·19		2·13
SiO_2/R_2O_3 (molecular)	1·61	1·67		1·59		1·51
Soil type	Non-lateritic	Non-lateritic		Non-lateritic		Non-lateritic

MAHA ILLUPALAMA

Elevation	Approx. 300 ft.
Climate	Rainfall 55 in. (approx.) ; temperature 80·5°F.
Geological origin ..	Recent and possibly dolomitic limestone residues over gneissic rock
Mode of formation ..	Sedimentary; alluvial; possibly residual
Drainage	Generally good, but somewhat impeded in parts
Topography ..	Flat
Vegetation	Natural : medium jungle ; cultivated *Citrus* spp., sisal.

PROFILE

A. 0-8 ft.	Chocolate red heavy loam of fairly uniform texture throughout small proportion of gravel ; profile ; compact; fairly hard but friable ; irregular columnar; root growth good.
B. 8-10 ft. ..	Reddish gravel layer in matrix of red loam.
C. $>$ 10 ft. ..	Decomposing rock.

The soil is a heavy loam of good depth, the drainage in parts being somewhat impeded. It has a fair supply of nitrogen but is poor in organic matter. Being well supplied with bases, it is neutral in reaction. The clay analysis indicates that it is of the non-lateritic type.

MINNERIYA

Elevation	300 ft.
Climate	Rainfall 73 in. temperature 81·5°F.
Geological origin ..	Charnokites and sedimentary metamorphic rocks dolomitic limestone
Mode of formation ..	Residual
Drainage	Good
Topography ..	Generally flat
Vegetation	Low to medium jungle ; cultivated *Citrus* spp.

PROFILE

A. 0-8 in.	..	Dark reddish brown loam, fairly high proportion of quartz and ferruginous gravel; hard when dry but fairly friable; compact; irregular clod; root growth good.
C. 8 in.-3 ft.	..	As above; reddish brown ferruginous nodules, partly decomposed, and quartz gravel in fair quantity, nodules more decomposed with depth.

This profile was taken in an area not far distant from the Department's citrus grove. The A and C layers are sandy loams, but the proportions of gravel in them are fairly high. The nitrogen and organic matter contents are fair in the A but poor in the C horizon. The A horizon is slightly acidic in reaction, having a lime requirement of about 15 cwt. per acre, but the C horizon is slightly alkaline. The replaceable base contents are fair, lime constituting only 60 to 65 per cent. of the total. The soil is non-lateritic in nature.

MINIPE

Elevation ..	..	300 ft.
Climate ..	..	Rainfall 86 in. (approx.); temperature 81°F. (approx.)
Geological origin	..	Recent
Mode of formation	..	Alluvial
Drainage ..	..	Good
Topography	..	Gently undulating
Vegetation ..	..	High jungle

PROFILE

A. 0-10 in.	..	Yellowish brown sandy loam loose and friable; quartz and ferruginous gravel occasionally found in lower portion of horizon; root growth good.
C1. 10 in.-4 ft.	..	Yellowish loam with reddish brown ferruginous nodules in varying stages of decomposition.
C2. $>$ 4 ft.	..	Decomposed gravel and ferruginous nodules in abundance.

The A horizon is a sandy loam, while the C is of a heavier loamy texture. The organic matter and nitrogen contents of the former are fairly low, and of the latter, low. The replaceable base contents are fair, but poorer than those of the majority of soils studied. The soils are acidic in reaction, the B horizon being less so. A lime requirement of about 15 cwt. per acre is indicated. The soil is of the non-lateritic type.

HAMBANTOTA

Elevation	40 ft.
Climate	Rainfall 42 in. (approx.) ; temperature 80°F.
Geological origin ..	Probably dolomitic limestone or Pleistocene plateau deposits
Mode of formation ..	Residual or transported
Drainage	Good
Topography ..	Flat
Vegetation	Natural : low scrub ; cultivated : fruits, citrus.

PROFILE

A. 0-6 ft.> ..	Brick red, deep loam of uniform texture ; friable ; compact ; irregular clod ; root development good.
C. > 30 ft. ..	Ferruginous pea-sized gravel in matrix of red loam, degree of decomposition increasing with depth.

The soil is a medium loam of considerable depth, poor in organic matter and nitrogen, fairly rich in bases of which calcium constitutes about 70 per cent., and alkaline in reaction. It is non-lateritic in nature and is probably derived from dolomitic limestone.

OTHER CITRUS SOIL TYPES

The Jaffna Calcareous Soils (2).—These are deep, free draining loams to heavy loams, rich in replaceable bases, phosphoric acid and potash, but poor in nitrogen and organic matter. They are alkaline in reaction. Irrigation is considered essential on them and so also is organic manuring. They will doubtless respond to nitrogenous fertilization.

The Nalanda Limestone Soils (2).—Like the Jaffna soils these are well drained loams to heavy loams, comparatively rich in replaceable bases, lime and potash, fair in phosphoric acid and poor in nitrogen and organic matter. They are neutral in reaction. Except perhaps in regard to irrigation, they should be treated like the Jaffna soils.

The Lateritic Loams.—These are similar to the Bibile soil described above, and are further detailed in an earlier paper (3). They have fair contents of nitrogen and organic matter, but are generally poor in potash and phosphoric acid. Being acidic in reaction they would probably benefit by liming. Organic manuring and a general artificial mixture would conduce to maintaining good yields. The dry zone lateritic soils (4) are similar to the wet zone types and their manurial requirements would be likewise. They would probably require to be irrigated during the dry season.

The Dry Patna Soils (3) are generally similar to the lateritic loams, but as their organic matter contents are fairly high, they will not perhaps require organic manuring for a year or two if care is taken to preserve the soil against erosion.

The Gravelly Loams (5).—Of poor quality for citrus, the more compact and harder types of lateritic gravelly (cabooky) soils should, whenever possible, be avoided for citrus growing. They are poor in all fertilising constituents, and though of low-water-absorbing capacity are inclined to be water-logged in rainy weather. Very liberal manurial treatment will be required on these soils thus rendering economic returns doubtful.

The Light Sandy Soils of the Marawila and coastal districts (4) so favoured for coconuts, are equally suitable for citrus because of their physical condition. Being poor in organic matter, nitrogen and mineral plant food constituents, they would require liberal applications of organic and inorganic manures and occasional doses of lime.

The Dry Zone Reddish Loams. These soils are of the Maha Illupalama type and require no further comment. Further soils of this group are the Vavuniya and Anuradhapura chocolate red loams described previously (6).

GENERAL DISCUSSION AND SUMMARY

The citrus soils described in this paper vary in texture from sands to heavy loams. They are all deep, well-drained soils with no physical obstruction to root development within a minimum of 4 feet. In choosing areas for citrus it is most important to study the soil profile. Rock, hardpan and stiff clay below the surface within a depth of 4 or 5 feet would be detrimental to the crop. An impermeable sub-soil, as would be the case under these conditions, prevents good root development and would render the soil water-logged in the rainy season. A sub-soil of gravel, especially in dry and semi-dry areas where irrigation is not feasible, may be disadvantageous as water percolates too rapidly through it, and in dry weather is not made available to the surface soil through capillary action. An area which is too rocky is also not to be recommended. The soils studied are neutral, alkaline or only slightly acidic in reaction. They are fairly well supplied with replaceable bases except the Mundel soil, and one, the Maha Illupalama soil, is rich in these constituents. All are poor in nitrogen and organic matter. With the exception of the Bibile soil, they are of the non-lateritic type. They would all require manuring with bulky organics like cattle manure, compost or green manure and would respond to applications of artificial fertilizer mixtures with nitrogen as the predominant constituent. Fertilizer experiments with citrus in other countries have demonstrated the importance of nitrogen to the crop, and there is every indication from the nature of these soils that nitrogenous fertilization would be necessary if the crop is to be kept in good condition and satisfactory yields are to be secured and maintained. It is probable that the premature death of citrus trees in certain parts of Ceylon, preceded by the mottling and chlorosis or yellowing of the leaves, is due in part to a deficiency of plant food, particularly nitrogen. This fertilizing constituent should be given partly as organics and partly as inorganics. On the lighter soils, *viz.*, those of Mundel, Minipe and Gokarella, potash and phosphoric acid would also appear to be necessary, but the other soils too may show the need for these plant food constituents.

The occasional liming of some of the soils—the Bibile, Minipe and Minneriya soils appears to be indicated. On the light citrus soils of Palestine which have even higher replaceable lime contents than many of these soils, liming has been found necessary. Lime appears to be essential for proper citrus growth (7).

The annual rainfall of the areas studied varies from 42 to 85 inches, but in practically all cases the greater part of the precipitation occurs during the three or four months of the north-east monsoon. A fairly long period of drought is therefore experienced during which irrigation would probably be found necessary in most of the areas, particularly on those with the lighter soil types. The irrigation need not be more frequent than once every ten days or fortnight, but must be as thorough as possible.

The other soil types in which citrus is grown in Ceylon have been referred to in the preceding section and the necessary manurial and other measures each would probably require have been specified.

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PRELIMINARY EXPERIMENTS ON SOYA INOCULATION IN CEYLON

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THE cultivation of the soybean (*Glycine max* (Linn.) Merr.) has during recent years extended remarkably in different parts of the world. The possibility of its cultivation in Ceylon has been considered for many years and from time to time experimental plots have been planted with soya. The results of these trials have been, on the whole, disappointing, but with awakening public interest it has been decided that extensive and detailed trials should be made to determine if a variety or varieties cannot be obtained which will grow well under local conditions. At the same time, it was realized that one of the limiting factors to successful cultivation might be the absence in some or all Ceylon soils of a suitable strain of the root-nodule bacterium which has been proved, for soya and other leguminous plants, to be such an important factor in successful cultivation. The experiments described below are part of this investigation.

Preliminary experiments were carried out to determine if increased nodulation of the roots of soya and the consequent improvement in growth could be induced by seed inoculation under Ceylon conditions. The results were satisfactory and a suitable inoculation technique was developed.

It is now well established that species of the root-nodule bacterium of leguminous plants exhibit specialization into strains varying in nitrogen-fixing ability. Some of the strains have been shown to be so inefficient as to be almost parasitic.

The subject has been reviewed by Fred, Baldwin and McCoy (1932). Variation in *Rhizobium japonicum* Kirchner, the root-nodule bacterium of soybean, has been investigated by Wright (1925 *a* and *b*) and by Harper and Murphy (1928). An essential preliminary to the extension of soya cultivation in Ceylon was therefore the selection of a strain of the root-nodule bacterium which would give the best results under local conditions.

METHODS

Four strains of *Rhizobium japonicum* were obtained for trial. Three of these, *viz.*, strains Nos. 73, 36 and 30 were kindly supplied by the Director of the Agricultural Experiment Station, Buitenzorg. These had been isolated from plants grown in soils of different types in Middle, Eastern and Western Java respectively. The fourth strain, which is here referred to as the Rothamsted strain, was originally strain No. 9 of the Wisconsin Experiment Station, Wisconsin, U.S.A., which had been introduced into England by the Rothamsted Experiment Station and has proved to be so efficient for English conditions that it is now sold commercially in England.

The following modification by Carroll (1934) of Fred and Waksman's (1928) yeast extract—mannitol agar was used for maintaining cultures of the bacterium :—

Asparagus extract	50	cc.
Mannitol	10	gm.
$CaCO_3$	3	gm.
K_2HPO_4	0·5	gm.
$MgSO_4$	0·2	gm.
NaCl	0·1	gm.
Agar	15	gm.
Dist. water	950	cc.

The medium was sterilized in an autoclave at 20 lb. pressure for 20 mins. The pH value of the medium was 7·2.

The experimental material consisted of a white-seeded variety of soya obtained from Poona. Very few viable seeds were available originally and these were multiplied in the preliminary experiments on inoculation methods which are mentioned above. Reference will be made to this point later.

The inoculation technique employed was that described by Thornton (1931). Bacteria were scraped from the surface of agar cultures in tubes and dispersed in a 0·1 per cent. solution of diacid calcium phosphate in skim milk. Thornton has demonstrated that both the calcium phosphate and the skim milk stimulate the formation of the motile coccus stage of the bacterium and so increase the chance of successful inoculation. Skim milk is preferable to whole milk as it dries faster. Seeds for inoculation were soaked in the bacterial suspension and then air-dried in a shady place. They were sown on the same day.

Twenty unglazed flower pots, 11 ins. in diameter, were filled with washed river sand. The sand was not sterilized nor is it likely that it was completely nitrogen-free. Each of four pots was planted with ten seeds inoculated with one of the strains of the root-nodule bacterium, while one set was planted with untreated seeds. There were thus four replications of five treatments. The seeds were planted at a depth of about 0·5 inch on 12th January, 1937.

In addition to the normal watering with tap water, each pot received each day 200 cc. of a solution of the following in tap water :—

$CaCl_2$	0·005 gm.
$MgSO_4$	0·005 gm.
K_2HPO_4	0·005 gm.
Fe_2Cl_6	a trace
Tap water	200 cc.

This solution supplied all the necessary inorganic substances except nitrogen. It had a pH value of 7·4.

The positions of the pots in the plant house were randomized and were changed at intervals. The plant house is so constructed that the plants received direct sunlight between 9 a.m. and 3 p.m. on each fine day.

RESULTS

Germination took place quickly and many young seedlings were visible two days after sowing. On 30th January, 18 days after sowing, excess seedlings were removed and five equally spaced seedlings were left in each pot. On 24th January, a

few seedlings in each treatment were examined but no sign of nodulation was observed on the roots. At the time of thinning out, however, nodules were present on all the plants in the inoculated series but none were seen on the control plants. The nodules were large and were clustered round the tap root near the collar—a type of nodulation associated with efficient nitrogen-fixation.

The first flowers were observed on the plants on 16th February and by 26th February all the plants except one had flowered. There was no obvious effect of treatment on the time of flowering. By the 12th March, pods had formed on all plants but the seeds were not filled and at this stage the plants were uprooted for weighing and for nitrogen-content determinations.

Once the cotyledons had fallen, the control plants exhibited a reduction in the size of the leaves and a marked chlorosis, especially along the veins, when compared with the plants from inoculated seed. The difference between the control plants and the others persisted until about a week before harvesting when the control plants showed a considerable degree of recovery ; the leaves that matured during this time were larger and less chlorotic. On examination at harvesting it was found that the roots of the control plants were nodulated, although the number of nodules per plant was notably less than in the inoculated plants. It is unlikely, however, that the results of the experiment were seriously vitiated by this accidental inoculation. The source from which infection occurred is not clear. The seeds were not sterilized and were obtained, as has been stated above, from plants which were grown in preliminary trials. It is possible that these seeds may have been infected with the root-nodule bacterium but, at the same time, this is not very likely since no nodules were seen on control plants at the time of the thinning out of seedlings, when the plants from inoculated seed were already freely nodulated. Other possible sources of infection were the sand, which was not sterilized, splashings from one pot to another during watering or accidental transference in handling the plants. Whatever the source of infection the ultimate effect was merely a tendency to reduce the differences

between the control and inoculated plants and so was not of vital importance.

In harvesting care was taken to remove all plants with as little injury as possible. The sand was washed from the roots in running water and the plants were superficially dried between blotting paper. The fresh weights of the plants from each pot were determined. The plants in each treatment were cut up into small pieces and bulked. Samples were drawn from this bulked material for nitrogen-content determinations and for dry weight determinations. The nitrogen estimations were made by the Kjeldahl method, in duplicate.

TABLE I

Strain of Bacterium	Pot No.	Dry wt. gm.	Mean dry wt. per pot gm.	Per cent. nitrogen in dry matter	Total nitrogen per pot gm.
73	1	7·86	8·50	3·13%	0·266
	2	9·37			
	3	8·82			
	4	7·93			
36	1	8·96	7·37	3·26%	0·240
	2	8·42			
	3	6·12			
	4	5·99			
30	1	6·93	7·24	2·94%	0·213
	2	7·76			
	3	7·53			
	4	6·74			
Rothamsted	1	7·04	7·08	2·68%	0·190
	2	5·81			
	3	7·55			
	4	7·91			
Control	1	4·22	5·43	2·38%	0·129
	2	5·77			
	3	5·77			
	4	5·96			

In table I are recorded the dry weights of the plants in each pot, as calculated from their fresh weights, and the nitrogen-content of each treatment. As might be expected, the dry weights run parallel to the figures for total nitrogen-content. The most efficient strain—No. 73—produced 8·50 gm. dry material and 0·266 gm. nitrogen per pot, whilst the most ineffective strain—the Rothamsted strain—produced 7·08 gm. dry material and 0·190 gm. nitrogen per pot. The percentage of nitrogen in dry matter was highest with strain No. 36, 3·26%, whereas strain No. 73 contained 3·14%. It is, however probable that the difference between the percentages of nitrogen in this instance is within the limits of experimental error.

The dry weight figures have been subjected to an analysis of variance (Fisher 1932) in table II. The value of F (Snedecor 1934) for treatments is above the one per cent. point, and the effect of treatment is accordingly highly significant. From the figures at the foot of table II it appears that the mean dry weights of plants in the case of all the strains—except the Rothamsted strain—are significantly greater than in the control, and that these various strains do not differ significantly from one another. The total nitrogen figure for strain 73, however, is very probably significantly greater than the figures for strain 30 and the Rothamsted strain.

SUMMARY

A preliminary experiment is described in which a comparison is made between the effects of seed inoculation of soybean, using four different strains of the root-nodule bacterium and uninoculated control plants. The strains used were Nos. 73, 36 and 30 from Java and a strain from England, which was originally No. 9 from Wisconsin. Plants were grown in sand in pots and were harvested just as the pods were beginning to develop.

Inoculation with strains Nos. 73, 36 and 30 from Java resulted in a statistically significant increase in the size of plants, as judged by their dry weight, over the control. There was no significant difference between the effects of the different strains.

The total nitrogen-content of the plants ran closely parallel to the dry weight of the plants.

TABLE II

ANALYSIS OF VARIANCE OF DRY WEIGHTS

Due to—	Degrees of Freedom	Sum of Squares	Variance	F	One per cent. point
Between treatments	4	19·30657	4·82664	5·21	4·89
Within treatments	15	13·89225	0·92615		
Total	19	33·19882			

Standard of Deviation = 0·9624

Coefficient of Variability = 13·51%

Mean Dry Wt. Per Pot in gm.

Strain 73	36	30	Rothamsted	Control	General Mean	S.E. of Mean of 4 plots	Significant difference
8·50	7·37	7·24	7·08	5·43	7·12	0·4812	1·665

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SELECTED ARTICLES

TROPICAL FRUITS AND VEGETABLES. AN ACCOUNT OF THEIR STORAGE AND TRANSPORT*

INTRODUCTION

IN this publication an attempt has been made to bring together an account of the storage and transport of a number of fruits and vegetables indigenous to, or capable of being grown in, the tropics. The successful cold storage of each commodity depends on a number of factors, including the variety, environmental conditions of growth, the maturity at which it is harvested, the rapidity and care with which it is removed to cold storage, the actual temperature, humidity and duration of storage, and the time required for distribution on removal from storage. Where available, information on these several topics has been included.

With rare exceptions tropical fruits are notoriously subject to wastage. Great care in handling and, almost invariably, the use of refrigeration are necessary before uniform supplies of attractive fruit can be made available on temperate markets.

Much of the literature on tropical fruit and vegetable storage is fragmentary and inconclusive, partly because the science of food preservation as a whole is yet in its infancy, partly because pre-storage factors exercise a profound influence on the subsequent storage life. Thus, a storage temperature found to be optimal for a particular fruit in one country may be quite unsuitable for the same fruit grown elsewhere. The investigator of such problems is, accordingly, brought into sharp contact with the many physiological problems pertaining to the development, ripening and senescence of fruits, and in particular with the effect of low temperatures on the processes of metabolism. In this paper, attention will be restricted to the major practical issues.

A surprising number of vegetables, usually regarded as temperate or warm temperate in habitat, have now been grown with a fair measure of success in the tropics. As progress is made in the breeding, selection and acclimatisation of new varieties, the production of such vegetables in the tropics will increase, if not for export at least for local consumption. The value of the short but highly productive cropping period, characteristic of tropical

* By C. W. Wardlaw (Low Temperature Research Station) in *Tropical Agriculture*, Vol. XIV, No. 3, March, 1937

conditions, can be greatly increased where refrigeration facilities are available to extend the consumption period. So far the relevant storage literature is scanty, and, of necessity, many of the storage temperatures cited refer to produce obtained under temperate conditions. While such data may be used as a guide in arranging local storage trials, it will generally be found that tropical produce requires higher storage temperatures in order that chilling may be avoided.

The uses to which refrigeration may be put in the handling of tropical produce are many and various. Cold storage may be resorted to in order to avoid glut periods locally or unfavourable marketing periods abroad. Where intended for export, fruit may be harvested relatively immature, transported at a suitably low temperature (which retards but does not entirely arrest maturation processes) and subsequently ripened at a higher temperature. On the other hand, the fruit may be harvested when it is practically "eating-ripe," and held at a low temperature until required for immediate consumption. As a rule, rapid cooling after harvesting is desirable. In some instances the practice of pre-cooling fruit is adopted: by this term is inferred the rapid cooling of fruit to the required transport temperature prior to its being stowed in the refrigerated hold ; this procedure has the advantage of giving uniformity of temperature to bulk consignments, and cooling at rates generally in excess of that possible on shipboard.

The prime factor in the overseas transport of perishable tropical produce is, of course, the refrigerated ship. The absence of suitable shipping has been and still is the chief obstacle to the wider utilisation of tropical produce. The type of cold-storage installation is important. As the tissues of stored fruits and vegetables are still alive, they require environmental conditions which will permit of approximately normal, though retarded, maturation so that the appearance, flavour, texture, aroma and other qualities for which they are prized, will be preserved. In general, the equipment and design of refrigerated holds should be such as to permit of rapid cooling, the maintenance of the steady temperature, relative humidity, and, if necessary, gas concentrations optimal for the fruit in question. In particular, carriage at too low a temperature, resulting in various types of chilling, which may be manifest during storage or subsequent distribution, should be avoided. Where, as in the older type of refrigerated ship, the holds are cooled by wall-grids, the resulting lack of uniformity in temperature involves considerable danger of chilling in the fruit in proximity to the grids and fungal wastage in the fruit remote from the grids where temperatures are high. In modern fruit ships this system is no longer used, refrigeration being supplied in the form of circulating air cooled to the required temperature by passing over cold pipes (the battery or air-blast system). The circulating air, which in time becomes vitiated by the carbon dioxide of respiration and by volatile substances given off by the fruit—which may accelerate ripening—is periodically discharged and a fresh supply taken into circulation.

The part which refrigeration can play in local food economics in the tropics should not be overlooked. Every year sees an increase in the extent to which it is being applied in the preservation of perishable produce. Its rational use cannot fail to be profoundly beneficial not only in handling produce intended for export but also in the conservation of locally produced foodstuffs.

ARTICHOKES

Two distinct and botanically unrelated kinds of artichoke are known : the true artichoke, known as the globe or French artichoke (*Cynara scolymus*—*C. cardunculus*) is a thistle-like plant, native to the Mediterranean region, the edible portion being the unopened flower buds. The Jerusalem artichoke or girasole (*Helianthus tuberosus*), which is neither an artichoke nor native to Palestine—it is of N. American origin—is grown almost exclusively for the edible underground tubers.

THE GLOBE ARTICHOKE

The heads are cut when they have attained their greatest size prior to the appearance of the floral parts.

According to Rasmusson the life of artichokes can be prolonged by cold storage at 32° to 33·5° F. for an additional period of four months over ordinary storage.

THE JERUSALEM ARTICHOKE

The Jerusalem artichoke or girasole has long been in general use in many European countries. In the United States of America, on the other hand, the plant, though widely known, is little used, and only recently has been given serious attention as a source of raw material for the commercial production of fructose (laevulose) and alcohol. Though the plant is best adapted to temperate regions, it can also be grown with some measure of success in the tropics.

As the tuber periderm is thin and easily ruptured, a rapid loss of moisture takes place when tubers are exposed to room temperatures ; wastage due to micro-organisms may also be considerable. The best method of storage, in temperate countries, consists in leaving tubers in the ground and digging them as required. Among earlier references Rasmusson states that tubers in cold storage at 32° to 33·5° F. kept for four months longer than in ordinary storage. Traub *et al.* in storage trials, observed that artichoke tubers may be successfully stored either as a truck crop or as propagating stock at 32° to 35° F. and relative humidity of 89 to 92 per cent. Under these conditions, tubers were found to have a larger amount of water-soluble carbohydrate per unit green weight than tubers left in the ground over winter. At temperatures above 40° F., stored tubers lose moisture rapidly, shrivel, and are so subject to diseases that the entire consignment may sometimes be lost.

Trinidad-grown tubers, subjected to air-blast refrigeration at 45° F., showed marked symptoms of desiccation (perhaps accompanied by some chill

injury). In still air at 60° F. tubers kept in good condition for two to three weeks but thereafter became mouldy.

ASPARAGUS

All the common varieties of this vegetable have been derived from one species, *Asparagus officinalis*, the genus being native to the Old World. Very full accounts are now available of the methods of planting, cultivating, harvesting and preparing for market.

Large, well-developed crowns or rootstocks are essential to the production of good asparagus. The spears or shoots are cut once or twice per day, according to the rate of growth. If white asparagus is desired the shoots must be cut just as they force their way through the surface of the soil as they quickly become green on exposure to light. In Europe nearly all of the asparagus sold in the fresh condition is white, but in the United States of America, it may be marketed with the spears entirely blanched, almost entirely blanched, with a green tip, or green throughout except for the butts. The green product is now becoming increasingly popular.

During the progress of the cutting season there is an increase in the sugar content of the shoots and a decrease in the protein and lignin. Photosynthesis carried on by shoot itself is thought to be a factor in the recorded sugar increase.

STORAGE OF PROPAGATING CROWNS

Propagating crowns, when hauled from the field, should be placed on a dry floor or on well drained ground. The best storage temperature is about 40° F. but, provided the atmosphere is dry and air circulation among the crowns adequate, storage for long periods at higher temperatures is also feasible. If the crowns become moist either from external dampness or from "sweating" in the heaps, they soon decay. Excessive desiccation of the crowns should be avoided.

PACKING

Fresh asparagus may be packed loose in the crate or bunched and crated, the latter procedure being the more usual. In the large producing areas in California, well equipped packing houses are provided for the several operations of grading, bunching and wrapping.

Tests in Georgia with asparagus wrapped with films of moisture-proof cellulose have shown that the loss in weight during storage is materially reduced and the storage life at ordinary temperatures prolonged. Recent work in Germany indicates the value of cellophane wrappers in the conservation of asparagus.

QUALITY CHANGES AFTER HARVESTING

Defects developing after harvesting include excessive wilting, elongation of the spears and opening up of the heads, rotting due to fungal and bacterial pathogens, and general deterioration in quality. Bisson, Jones and Robbins

have analysed the several factors involved, standardised samples being stored at 33°, 41°, 56°, 77° and 95° F., and examined microscopically and chemically at intervals of 24 hours. Their results show that green asparagus should be bunched, packed and placed under refrigeration—just above 32° F.—as soon after harvesting as possible, since certain changes in structure and chemical composition, which affect the edible quality, take place with great rapidity.

Asparagus spears grow in length and increase in weight in the crate if the butts are resting on moist moss. The growth rate is least at 33° F. but increases with temperature. The greatest increase in length takes place during the first 24 hours after cutting, hence the necessity for rapid cooling. During storage at higher temperatures, 75° to 95° F., mould appears on the spears within a few days. A loss in reducing substances and in total sugars takes place at all temperatures, especially from 56° to 95° F., the maximum rate of loss occurring during the first 24 hours.

At all storage temperatures there is a definite increase in the amount of fibrous material. This could be demonstrated microscopically and also by estimating the amount of crude fibre present. The increase in fibrous material takes place most rapidly immediately after harvesting. Its formation is accelerated at the higher and to some extent arrested at the lower temperatures. The initial toughness of the spears may therefore be accentuated by unfavourable storage conditions.

PRECOOLING AND COLD STORAGE

It has been seen that asparagus loses much of its food value, and therefore its saleability, within a few hours after cutting unless it is placed in storage at a relatively low temperature. According to Platenius, Jamison and Thompson no other vegetable deteriorates so rapidly as asparagus at ordinary temperatures. If the bunches are stood on damp packing and stored at 32° F. immediately after cutting, this commodity should keep in good condition three to four weeks. If received at the storage plant after a long haul from a distant point of production it cannot be expected to keep longer than three to six days.

In California the larger consignments, at the height of the season, are precooled before being loaded into refrigerated cars, the cars being re-iced as required during the transport period. According to Hanna it usually takes from 8 to 12 hours to bring the temperature down to 40° F. All-green asparagus, which has a higher respiration rate than spears with white butts, takes longer to cool. Temperatures of 33° F. and R. H. of 90 per cent., 32° to 35·5° F. and R. H. of 80 per cent. are cited as being suitable for asparagus storage over periods of 21 to 50 days. Platenius *et al.* quote a storage temperature of 32° F. and R. H. of 95 to 98 per cent. as affording a maximum storage period of one week. The use of ozone in asparagus storage has been considered by Kochs in Germany; in these experiments the

duration of storage at various low temperatures could not be prolonged beyond two to three weeks.

GAS STORAGE

In gas storage experiments, Brooks *et al.* found that asparagus exposed to early treatment with carbon dioxide (*i.e.*, during cooling) showed improved appearance, keeping quality and flavour over untreated control lots. "Asparagus exposed to 25 to 30 per cent. of carbon dioxide at temperatures of 60° to 70° F. for 18 to 24 hours had a better flavour than asparagus held at the same temperature without carbon dioxide and as good as or better flavour than asparagus held at 32° or 40° F. for the same period. Asparagus that was exposed to 25 to 30 per cent. of carbon dioxide for 48 hours or to 40 per cent. or more of carbon dioxide for 24 hours was sometimes found to have an objectionable flavour." Thornton has reported a browning of the outer bud scales and the development of water-soaked areas as asparagus exposed to 50 to 80 per cent. of carbon dioxide for 3 days. Early treatment with carbon dioxide was also effective in controlling fungal rotting.

AVOCADOS

The avocado, also known as the avocado pear, ahuacate, zaboca, alligator pear, midshipmen's butter, &c., is derived from several species of Persea (Lauraceae) indigenous to the West Indies, Central and South America, upwards of 400 varieties having now been recognised and named. In California and Florida the industry is extensive, large consignments of fruit being sent by rail to the centres of population throughout the United States. The fruit is also grown for export in Cuba, Porto Rico and Hawaii. Attempts to build up an export industry are now being made in British West Indian Islands. The fruit is prized for its rich nutty flavour and for its high oil and protein content. According to one authority the avocado promises to become one of the five great food fruits of the tropics of both hemispheres within a generation.

PICKING AND PACKING

The maturity at which fruits are picked is determined by the length of storage life required, but immature fruits should be avoided as they tend to be inferior in flavour on subsequent ripening.

As avocado varieties show profound variations in respect of size, shape, colour, skin-texture and other characters, only local experience can prescribe the exact picking maturity for any particular variety. In California fruits are tested in the laboratory for oil content—which increases with maturity—as a means of determining when picking should take place, but this criterion, though helpful, is not absolute. Though fruit intended for storage is picked in a firm and inedible condition, nevertheless it must have reached a stage of maturity which will permit of normal ripening. Where a storage life of 20 to 25 days is required (*e.g.*, 14 to 18 days in cold storage during overseas transport, and 7 to 10 days for ripening and distribution) colouring varieties, *i.e.*, with red, purple or pale yellow skins, grown under West

Indian conditions, may be picked when they show the first trace of colouring. With green varieties the precise picking maturity is more difficult to determine and depends largely on personal judgment. The investigations of Stahl indicate that specific gravity tests may be useful in determining picking maturity.

Picking is done by means of citrus clippers, the fruits being carefully placed in padded field boxes to avoid bruising during transport to the packing shed. In California and Florida the fruits are washed and graded by machinery for weight, and packed in single layers with excelsior in flat 13-lb. boxes, ten packing sizes being recognised according to the size and shape of the fruit. The ideal avocado for export has been described as a spherical fruit weighing approximately 1 lb.

In Florida the lug commonly used holds approximately 15 lb. of fruit, and has inside dimensions of $15'' \times 13'' \times 3\frac{1}{4}''$, $3\frac{3}{4}''$ or $4\frac{1}{4}''$ according to the size of the fruit. Tomato crates $12'' \times 12'' \times 24''$ (ventilated crates capable of holding about 40 lb.) may also be used, with a light wadding of excelsior to support the fruits and minimise bruising. Wrapping individual fruits and close packing with wood-wool, excelsior, &c., should be avoided to eliminate the tendency to self-heating. Where very mature fruit has to be railed long distances in hot weather, special crates bunkered with 12 to 20 lb. of ice according to the type of construction are fused.

STORAGE TEMPERATURE AND DURATION OF STORAGE LIFE

Among earlier investigations, Condit reported that Mexican avocado varieties, cultivated in California, kept well for one month in cold storage but subsequently deteriorated through shrivelling and decay; the Challenge variety was stored satisfactorily at 32° F. for six weeks; softening took place more rapidly in fruit held at 36° F. than at 32° F. Overholser dealing with avocados grown in California, found that a temperature of 40° F. was satisfactory for all varieties tested except the Fuerte which required 45° F. to prevent blackening of the skin. In general a temperature of 32° F. was too low as it led to discolouration of the flesh, though indications were obtained that some varieties might be satisfactorily held at 32° to 35·6° F. Under proper storage conditions some varieties could be kept for approximately two months, others for five to six weeks, and others for four weeks. Quick storage after harvesting and care in handling improved the keeping quality of fruits. Fruits picked just before commencement of softening kept best and attained excellent quality.

As early as 1907 Higgins in Honolulu referred to the successful export of avocados in cold storage to San Francisco (approximately seven days) with subsequent distribution by rail. More recently Harold found that Hawaiian avocados may be stored green at 36° F. for six to eight weeks, thereafter ripening satisfactorily in two to five days. Wilcox and Hunn have recorded the successful storage of Hawaiian avocados at 32° F. and 36° F., fruit having kept in good condition for periods up to 65 days.

Edwards and Guerrero have described trial shipment of avocados between Guam, Marianne Islands, and Manila. The fruit, held at 40° F. during the voyage of 16 days, was discharged in good condition.

The earlier records dealing with varieties grown in the West Indies are scanty. Unsuccessful attempts to export fruit from Porto Rico are mentioned by Griffith and Shill has briefly described experiments with small lots of fruit held at 45° to 50° F. in Dominica with subsequent removal to tropical temperatures (average 85° F.). After being held in cold storage from 6 to 10 days, the fruit, on exposure to the higher temperatures, ripened up with such rapidity as to make for considerable loss, internal blackening being a characteristic feature.

Californian fruit, if intended for the local market, is held in storage at ordinary temperatures until sufficiently soft for consumption. If required, fruit may also be held in cold storage at 40° to 45° F., some varieties having been kept in good condition for as long as two months. Fruit to be despatched by rail to eastern United States markets is precooled at 40° to 45° F. for 48 hours and then placed in refrigerated cars, this class of fruit being still firm when it reaches the hands of the retailer. Provided it has been properly selected and treated, shipment to the eastern seaboard by way of the Panama Canal has also been shown to be a commercial possibility.

In 1933 and 1934 investigations conducted in Trinidad on upwards of thirty West Indian seedling varieties showed that only a few could be held at a temperature of 40° F. for 20 to 25 days without sustaining low temperature injury. On the other hand, a higher storage temperature, *e.g.*, 50° F. was found inapplicable because of the tendency of fruits to ripen before the required storage life had been achieved. These general conclusions referring to the storage of seedling varieties have been confirmed by work in Jamaica.

Even at relatively low temperatures, maturation processes slowly continue so that fruits ultimately become ripe and finally over-ripe. In the few varieties which are sufficiently cold-resistant or tolerant of low temperatures, such ripening apparently takes place in a more or less normal manner, the flesh at maturity being of good flavour and free from internal breakdown, discolouration or other obvious abnormalities. On the other hand, in the majority of varieties, *i.e.*, those which do not possess adequate cold resistance, maturation processes also continue but it is evident that the metabolic trend is abnormal. Thus although such fruits eventually become soft in cold storage, inspection of the flesh at once shows that chill effects have been induced. The range in genetical constitution exemplified by avocado varieties is strikingly demonstrated in the matter of cold-resistance : this extends from varieties subject to chilling after 15 days at 53° F. to those which ripen normally during 40 days at 40°F.

CHILLING

The possibility of developing an export industry in avocados in the West Indies and elsewhere where delicate varieties intolerant of low temperatures are cultivated, largely rests on the question of cold resistance. In

varieties subject to chilling at 45° F. evidence of low temperature injury may be observed at an early stage, the flesh becoming discoloured while fruits are still hard and unripe ; despite the presence of this pathological condition, however, such fruits continue to ripen, and ultimately become quite soft, with further accentuation of the internal discolouration. Short of killing tissues outright by freezing therefore, it may be inferred that vital processes are involved both during the initiation and subsequent development of chill effects.

Various manifestations of chilling occur in fruit exposed to air-blast refrigeration. Necrosis of the skin in proximity to the stem-end, or brown, circular or confluent blemishes distributed over the skin, may sometimes be observed. Skin necrosis, however, is not usual, the large number of varieties showing internal chill effects being normal as regards external appearance. Internal chill effects are easily observed. While still firm, the flesh on cutting is seen to have acquired a slightly dark, smoky or brownish discolouration. In some varieties this is chiefly located next the stone, in others it may occur in the tissue mid-way between stone and skin. Again, in some instances the incipient chill symptoms may take the form of thin streaks as seen in longitudinal section, in others as isolated circular patches distributed towards the middle and distal regions of the fruit. Chilling of the flesh becomes accentuated with the onset of final maturity and culminates in a more or less general discolouration of the entire tissue to a smoky-brown, chocolate-brown or black appearance. Low temperature injury has also been described as giving the flesh a greyish appearance. In Californian avocados, Horne has described a darkening of the flesh sometimes associated with frost injury on the tree but in other instances due to other causes as yet uninvestigated.

In some varieties, either in conjunction with, or in the absence of discolouration of the flesh, the vascular strands which run longitudinally through the fruit may lose their clear, inconspicuous hyaline character and acquire a characteristic brown or blackish necrosed appearance by which they are rendered very conspicuous. In the matter of flavour, palatability in some varieties is only slightly impaired, whereas in others the nutty quality of the normally ripened fruit is replaced by a pasty, insipid flavour, or more or less acrid flavours may be induced.

Chilling is a complicated phenomenon in which various factors are involved. Among others the temperature and duration of storage are important : some varieties ripen normally after 20 days at 45° F. whereas during storage at this temperature for an additional ten days chill effects develop. The maturity of fruit at the time of storage is also of critical importance : fruits stored immature only show chill effects after long exposure to the low temperature, *i.e.*, after a certain stage in ripeness has slowly been reached, whereas fruits of the same variety stored more mature may show

chill effects in a relatively short time. In general, the evidence available indicates that fruits are most subject to chilling during the initiation of ripening.

GAS-STORAGE

Collectively the data obtained from gas-storage experiments show that by using subnormal concentrations of oxygen alone, or in conjunction with high concentrations of CO_2, a definite deceleration can be induced in the maturation of avocados. The range of tolerance to such treatments, however, varies from variety to variety, being comparable though not necessarily parallel to the response of different varieties to low temperatures. In varieties unsuited to gas-storage, external and internal damage may be sustained without the intervention of micro-organisms. In other varieties, although no direct physiological injury may be apparent, the fruits subsequently prove much more susceptible to the inroads of storage pathogens. Others, again, show surprising tolerance of gas-storage conditions and would undoubtedly lend themselves to commercial preservation by this method. It is interesting to note that in this category are varieties subject to chilling and consequently unsuitable for transport at low temperatures. Overholser showed that Fuerte avocados which could only be held for ten days at 70° to 80° F., and for one month at 45° F., could be kept in good condition for two months at 45° F., provided they were maintained in an atmosphere of four to five per cent. oxygen and not more than four to five per cent. CO_2. Furthermore he observed that excessive concentrations of CO_2 did not result in the production of objectionable flavours, but prevented softening of the flesh, so that it remained tough even after removal from storage.

BANANAS

Bananas rank as one of the most important crops throughout tropical and sub-tropical regions and in some countries constitute the major source of agricultural wealth. In the course of a few decades, from small experimental shipments, a large and important export trade has developed in different parts of the world.

From the point of view of cold storage, the banana is in many ways unique even among tropical plants : it produces bunches all the year round, thereby obviating the need for storage over long periods ; bunches are harvested quite green and for most markets less than full grown ; they are transported for long distances, mostly without any crating or other protection, and are eventually ripened up in a few days under controlled conditions in specially constructed rooms. A knowledge of the correct stage of maturity for harvesting and the precise conditions for transport and ripening is essential to the production of attractively coloured, well-flavoured fruit.

As a rule the banana has to be transported over long distances before it is available for consumption in temperate lands. Not only is the bunch habit conducive to bruising, but the onset of final maturity can only be delayed

to a certain extent by refrigeration. The fruit when approaching ripeness is very susceptible to fungal attack and, in consequence, considerable rotting may sometimes take place before the normal period of commercial handling has elapsed.

VARIETIES OF COMMERCE

The principal varieties of commerce are the Gros Michel, cultivated extensively in Jamaica and in Central and South America, and the Cavendish, Canary or Dwarf variety grown in the Canary Islands and Brazil for export to Britain and Europe, in Queensland for distribution in other parts of Australia, in Samoa for export to New Zealand, and in a number of African colonies and protectorates for export to Europe. The Lacatan or Giang Fig variety, is exported in small quantities from Brazil to Europe. There is some trade in the Giant Governor between the French Antilles and France. Many other varieties, possessing great delicacy of flavour and texture, are also known but so far, because of transport and ripening difficulties, they have only been used for local consumption. The Red banana which is occasionally seen on British and American markets is chiefly valuable for decorative purposes ; actually it is rather coarse and of mediocre flavour.

CLASSIFICATION OF FRUIT FOR EXPORT

In Central and South America and the West Indies, export bunches are divided into *classes* according to the number of " hands " or clusters on the stem and into *grades* according to maturity. A nine-hand bunch is taken as the standard, bunches of 8, 7 and 6 hands being priced at $\frac{3}{4}$, $\frac{1}{2}$ and $\frac{1}{4}$ respectively that of the standard or " count " bunch. In the Canary industry, a recognised system of lettering (*e.g.*, G. *gigantic*, Ex., *extra*, Esp., *especial*) indicates the type and quality of fruit contained in the crates. Other systems of classification are also encountered.

The usual grade of fruit shipped from Jamaican or Caribbean plantations to British and Continental markets is described as " standard " or " thin $\frac{3}{4}$-full"; less mature fruit is described as " thin "; for the more distant American markets fruit is reaped " heavy $\frac{3}{4}$-full " and for nearer markets " full." " Standard $\frac{3}{4}$-full " fruit is, as nearly as can be conveyed by verbal description, fruit which is beginning to fill out (so as to give a circular cross-section) but in which the ridges are still conspicuous. The less mature the fruit the longer, other things being equal, will be its storage life. It cut too immature, however, bunches ripen badly or not at all. In some varieties, *e.g.*, the Giant Governor, the size and appearance of the bunch, relative to the Gros Michel, are misleading as a guide to maturity. Thus, unless bunches are cut at a stage corresponding to " full " in the Gros Michel, they fail to ripen normally after the usual period in cold storage.

ORGANISATION IN THE BANANA INDUSTRY

The banana industry is dependent for its success on a very elaborate but precise organisation. This may be illustrated by a simple example. In

Central America a ship may leave with a cargo of 100,000 Gros Michel bunches, the total length of time elapsing between the commencement of reaping and the closing of the hatches being 36 hours or less. It is known that undue delay at this stage is liable to result in excessive wastage later.

On the plantations an exact schedule is followed so that reaping operations and local transport may be effected in the shortest possible time. Where wharfside facilities are available, mechanical elevators are used to charge the fruit into the holds. To convey the fruit to its destination, specially constructed ships with holds cooled by air-blast refrigeration have been designed. Finally, an efficient distributing system, involving the use of carefully controlled ripening rooms, ensures that fruit at the correct stage of maturity is constantly available to consumers in all parts of the country.

METHODS OF HANDLING FRUIT

In handling bananas a number of different methods have been evolved. These fall into two definite categories in which the fruit—

(i) travels carefully packed in crates or other containers, or

(ii) is stowed "naked," or simply protected by a paper bag, in bulk.

(i) *Crated Fruit.*—The export of crated bananas is best exemplified by the industry in the Canary Islands. There the chief variety of commerce is the Dwarf, Canary or Cavendish variety, a plant yielding an attractive sweet fruit esteemed on British and European markets. Not only is the Canary banana very susceptible to bruising because of its thin skin, but the disposition of the individual fingers, and the shape of the bunch as a whole, contribute in a large measure to its liability to mechanical injury. For these reasons the export industry has been developed on a system of careful handling, packing and crating.

To ensure the production of attractive fruit for export, the bunches receive attention from the time they are "shot" or "born" in the plantation. As soon as the young bunch (inflorescence) emerges, the number of the month is stamped on the stalk to facilitate estimating the time of maturing. The large bracts associated with the hands, the perianth-remains, and the terminal bud of male flowers, are removed at an early stage to get rid of potential sources of fungal infection. In due course, as the bunch becomes heavy, a strut is inserted under the slightly inclined trunk to give it support. The bunches of fruit are carefully reaped and conveyed by various means, on the head, on pack animals, or even on aerial rope-ways, to packing sheds. There the bunches are graded and packed into wooden crates or cardboard drums. The hexagonal crates are usually lined with straw or banana trash (old dried leaves); the bunch, wrapped in cotton-wool and covered with paper, is then carefully placed in position and firmly fixed by pressing the straw or trash around it. The slatted top of the crate is then nailed down. Such crates may contain one or several bunches. When three bunches are being crated together two are placed parallel and one transversely. Packing

fruit in cardboard drums is used chiefly in the export to Spanish markets where less handling is involved.

The crating adopted in the Canary Islands entails considerable expense. On the other hand, wastage due to mechanical injury and fungal activity is at a minimum. Further, as the period of ocean transport is relatively short, consignments of fruit can be stowed as ordinary cargo without refrigeration. In Britain the bunches are usually allowed to ripen in the crates, but on the Continent it is the customary practice to hang them up for ripening.

In Martinique and Guadeloupe large cases 1·5 m. by 1·25 m., padded with straw and capable of holding 24 wrapped bunches (weighing 600 kg.) have also on occasion been used for the Giant Governor and Cavendish varieties.

The Canary Islands system, more or less modified, has been adopted in Italian and French Somaliland, French Guinea and the French Antilles where the Cavendish is also the variety of commerce.

In Queensland, where the industry is also based on the Cavendish variety, fruit for local consumption is handled in the bunch. Bananas intended for the southern markets, on the other hand, are cut from the bunches and packed in wooden cases for transport by rail. The fruit, packed as "hands," "clusters" of about four fingers, or "singles" (this is the most common method), is ripened without removal from the case.

> "The hands are cut from the bunches and the individual fruits are cut or broken off and packed into paper-lined cases. The cases which measure internally 24¾ in. by 12 in. by 12 in., have solid ends, and sides composed of two or three pieces of wood fitting closely together. The top and bottom are formed of two or three slats with gaps at the edges and between them, of about ½ inch. In packing, the paper lining closes up these openings unless, as is customary in summer, it is torn at the gaps after the lids have been nailed down."

The cases are then sent by rail to Sydney, Melbourne and Adelaide, journeys of approximately two, four and five days respectively. There is also some trade to Western Australia chiefly by boat from Melbourne, making a total journey of 11 days. Consignments are also carried on the transcontinental railway, a total journey of ten days. The bananas on arrival in the southern cities are still green and must be ripened artificially. The overland transport of crated fruit, during summer and winter, from Queensland to other parts of Australia has its own particular problems and difficulties. These have been the subject of official investigations but their specialised nature precludes discussion here.

The advantages of the Queensland system are those of economy of packing and freight, the utilisation of fruit from small bunches, and the carriage of varieties in which the finger is too readily detached from the stem for transport

in whole bunches. The disadvantages lie in the more rapid and uneven ripening of consignments and the higher incidence of fungal wastage due to pathogens gaining access through the cut finger stalks (*i.e.*, "black-end" or "finger-stalk" rot and "squirter" disease). It has been suggested that, to some extent, wastage might be curtailed by precooling the bunches prior to the cutting or breaking off of the fingers and packing in pre-cooled crates.

In the export industry from Samoa to Wellington, New Zealand, the fruit is packed as "singles" in cases containing approximately 90 lb. During the ocean voyage of 11 days, although the holds are refrigerated, this method of handling may lead to a considerable amount of wastage.

Bunches for export from Formosa to Japanese markets are cut up into hands and packed in bamboo baskets giving a pack of approximately 100 lb. weight.

(ii) *Transport of "Naked" Fruit.*—The extensive export industry from Caribbean banana-lands to American and European markets is based on the Gros Michel banana. Not only has this variety a sufficiently tough skin to withstand the bruising consequent on normal handling but its strikingly cylinderical bunch habit enables it to be stowed "naked" in bulk without undue loss resulting from mechanical injury. Crating is precluded by high labour and freight charges, and by the enormous quantities of fruit shipped. On some plantations, however, all bunches are enclosed in stout paper bags in order to minimise mechanical injuries. The supremacy of the Gros Michel in the world's markets is due to its suitability for transport in bulk, and its good appearance and flavour on ripening.

Following the lines successfully adopted in Caribbean banana plantations, and industry using the Dwarf Cavendish (or Canary) and Giant Fig varieties has been inaugurated round the port of Santos in Brazil. Prior to reaping, paper pads containing trash are inserted as required between the first, second and third hands; a stout perforated paper bag is then slipped over the bunch and tied at the neck. The bunch is harvested and shouldered or headed out to the nearest tram-line. From there bunches are conveyed to the riverside, where they are loaded on to specially built barges. The latter are then towed down the rivers or along the coast to the ships. Loading is achieved by means of mechanical conveyors, or, if the ship is lying out at sea, by large basket crates operated by the ship's winches. Stowage is in bulk as described below for the Gros Michel, refrigeration being supplied in the form of a cold air blast.

For Cavendish fruit grown in the Canary Islands, French Guinea, Guadeloupe and Martinique, the stout paper bag is not considered adequate for the protection of bunches, and a more elaborate wrapping in cotton-wool wadding, kraft-paper and straw has been adopted (Kervegant). A somewhat similar protection is given to fruit exported from Hawaii to the United States.

Handling and Stowage of Large Consignments.—Practical experience and scientific investigation have shown that it is of the utmost importance to reduce to the minimum the time between reaping fruit and charging it into the holds and commencement of refrigeration. This is usually 36 hours or less. The importance of exact shipping schedules and shore organisation has already been emphasised. Before being loaded into the holds, bunches are inspected on the wharfside and all stem-ends are retrimmed and treated with a fungicide to minimise rotting by fungal organisms. Bunches which pass the inspectors are placed on specially designed, adjustable conveyors which, working on the endless-belt system, carry the bunches into the holds. There they are removed by a gang of workers and stowed compactly in the bins into which the hold space is divided. As a rule, two or three tiers of fruit are stacked with the bunches—large end downwards—in a vertical position ; a top layer occupying a more or less horizontal position, is used to fill up any remaining space. As soon as a hold is charged the hatches are closed and sealed and refrigeration is commenced.

CONDITIONS DURING OVERSEAS TRANSPORT

Bananas cut approximately "$\frac{3}{4}$-full," if left at tropical temperatures, would ripen up in the course of five to eight days. Refrigeration is accordingly, essential to the overseas transport of the banana, firstly to delay ripening and senescence, and secondly, to curtail the activity of rot-producing organisms.

Cooling of fruit is achieved by means of air-blast refrigeration, the holds being precooled prior to stowing the cargo. Experience has shown that 53° F. is the temperature best suited to the storage of $\frac{3}{4}$-full Gros Michel bunches where the period of ocean transport is about 16 to 18 days. This temperature should be attained as quickly as possible so as to check the activity of fungi, but it is important that the delivery air temperatures should not fall below 53° F. or the fruit will be chilled. Once or twice per day, according to requirements and opportunity, the air circulating in the holds is completely blown out, so as to avoid adverse effects which might result from the excessive accumulation of carbon dioxide or volatile substances. Fruit intended for the nearer American ports is exported from the Caribbean region in ventilated holds without refrigeration.

The relative humidity in fully charged banana holds is usually high, ranging from 80 per cent. almost to saturation. Sometimes it is in the region of 95 per cent.—a degree of humidity which encourages the superficial growth of moulds and mutual contamination of fruits. From the point of view of wastage control, therefore, a reduction in the relative humidity would be advantageous provided it was not such as to cause excessive dehydration with concomitant shrivelling.

During transport, the banana holds are inspected daily by the ship's officers and all bunches showing evidence of ripening are removed. Otherwise

accelerated ripening of green bunches by volatile substances given off by the ripe fruit may be experienced.

STORAGE TEMPERATURE

Precise knowledge of the carrying temperatures best suited to different varieties and grades of fruit is essential to avoid chill effects.

For the Gros Michel it has been shown that chilling was not produced by :

(i) cooling to 52° F., no matter how rapidly, provided the temperature of the delivery air was not below 52° F. ;

(ii) exposure of fruit to 52° F. for 4 days and then to 53·6° F. for 4 days and then to 53·6° F. for 11 days ;

(iii) exposure of fruit to 53·6 °F. for as long as 24 days.

From storage trials conducted at 51° to 52° F. it was found that chilling is a cumulative effect of duration of exposure, and is not the result of rapid cooling to such temperatures. In practice the Gros Michel banana is usually transported at a temperature of 52° F., and may be cooled to this temperature as quickly as possible, provided the delivery air does not fall below this temperature.

From studies conducted on fruit grown in Trinidad the Dwarf or Cavendish variety appears to be slightly more cold-resistant than the Gros Michel. The Lacatan (or Giant Fig) and the Congo on the other hand, are less cold-resistant and require a hold temperature of 58° to 60° F. in order that chill effects may be avoided. For the Giant Governor the storage temperature lies in the vicinity of 56° to 58° F. The hybrid varieties I.C. 1. and I.C. 2, bred from the Gros Michel as female parent and a wild seeded variety as male parent, behave like the Gros Michel in cold storage. The Red banana carries well in storage at 53° F. A variety known as Fillbasked ripens well after being stored at 53° F.

SYMPTOMS OF CHILLING

Certain physiological maladies, such as "green-ripeness"—as the name implies, the yellow skin-colour is poorly developed while the pulp within is soft and fully matured—may be caused by too high ripening temperatures. More commonly, however, the physiological diseases of commerce are due to "over-refrigeration" or chilling on shipboard.

In green bananas chilling may be difficult to recognise externally ; it has been identified in a general way by an increased development of brown streaks in the sub-epidermal tissues, this characteristic colouration being associated with the mucilage ducts. During ripening, chilling is easily recognised by several abnormalities :

(i) delayed ripening, and, in severe cases, complete failure to ripen ;

(ii) hardening of the central placenta—more pronounced in the Cavendish than in the Gros Michel;

(iii) assumption of a dull yellow colour instead of a healthy bright one; in the Gros Michel, as ripening proceeds, the dull yellow is replaced entirely by a dull russet colour, which later darkens; a dark mottling, associated with desiccation of the tissues, may also occur; this russetting of the whole bunch has not been noticed in the Cavendish, even when kept for 50 days at 52° F.; (in point of fact, it is sometimes rather difficult to recognise chilling in this variety, as fruit picked at an immature stage shows, on ripening, hardness of centre, dullness of colour, a tendency to browning—not typical Gros Michel russetting—characteristics which might be mistaken for chill effects; when definite chilling is produced in Cavendish types, including the Lacatan and Giant Governor, it is readily recognised during ripening at 70° F. by the assumption of a dull, sooty, ashen colour; green fruits also show a characteristic browning, particularly in the region of wounds or abrasions);

(iv) complete loss of banana flavour or the presence of a strange "cold-storage flavour";

(v) "green-ripeness" and "hard-ripeness."

LIMITS OF CHILLING

The following experimental treatments have yielded evidence of chilling:

(*a*) *Gros Michel*, (i) exposure of 14 days at 52° F.; (ii) exposure of 9 days at 51° F.;

(*b*) *Cavendish*, exposure of 13 days at 51° F.

Provided standard fruit is used, chilling can readily be avoided by paying attention to the temperature of the air-blast at the delivery side. The fact that rapid cooling to 53° F., by delivering air at that temperature, can be practised without danger of chilling permits of wastage control by curtailing fungal growth.

It has been found that heavy $\frac{3}{4}$-full Gros Michel bunches are more susceptible to chilling during long ocean voyages than standard $\frac{3}{4}$-full, and that the Giant Governor and Lacatan varieties are subject to chilling at temperatures below 56° to 58° F. Olney has recorded chilling as occurring in Gros Michel bunches (imported into the United States and therefore most probably heavy $\frac{3}{4}$-full) held at a temperature of 54·6° F.

Young *et al.* experimenting with the Cavendish variety in Australia (Brisbane) obtained the following data on susceptibility to low temperature injury.

(*a*) Storage at temperatures down to 45° F. for four days did not in any way affect the appearance of green bananas.

(*b*) Storage at 50° F. for periods up to four days caused a delay of up to one day in the subsequent colouring of the bananas, but apart from this there was no appreciable effect on the ripening.

(*c*) Storage at 45° F. for two days caused a delay in colouring of about one day, but apart from this there was no appreciable effect on the ripening of the fruit.

(*d*) Storage for four days at 45° F. had no appreciable effect on the subsequent ripening of the pulp of the bananas, but it caused a considerable delay in the colouring, and the fruit had a definitely greenish colour when fully ripe.

(*e*) Storage at 33° F. for 1½ days, or at 40° F. for 3½ days, produced a definite change in the appearance of the green bananas.

(*f*) Storage at temperatures below 45° F. had a more marked effect on the subsequent colour development than storage at 45° F., and it also tended to reduce the life of the fruit after ripening.

The cooling necessary to bring about "chilling" appears to vary with the temperature conditions under which the fruit is grown, winter-grown fruit being considerably less affected by low temperatures than summer-grown fruit. On the other hand, winter-grown fruit is more sensitive to high temperatures in the ripening rooms than summer-grown fruit.

Chilling has usually been attributed to exposure to cold conditions during transport, but it appears that a considerable proportion of it is due to exposure to low temperatures on the plantation probably before the fruit is cut from the plant.

Collectively the observations set out in this section indicate that, during the overseas transport of fruit, it is not only necessary to apply refrigeration at the tropical end but, during winter, it may be necessary to supply heat to the holds as the temperate regions are approached. In modern ships provision is made for this contingency.

THE EFFECT OF QUALITY ON STORAGE AND RIPENING

The quality of bananas varies considerably according to variety, the conditions under which they have been grown, and the procedure adopted during storage and ripening. Thus although the Gros Michel is the principal variety of commerce, it is not the variety most esteemed by connoisseurs, the Cavendish being preferred for its more sugary pulp and the Lacatan for its aroma, texture and sweetness. There are also many varieties used for local consumption throughout the tropics compared with which the Gros Michel is a relatively coarse fruit.

Within any one variety, such as the Gros Michel or Cavendish, considerable variation in quality may also occur. Thus the Cavendish variety as grown in the Canary Islands is a relatively small, sugary fruit whereas, under the

moist tropical conditions in the Caribbean region, the fruit is much larger and, according to general opinion, of poorer flavour.

The size of the fruit grown in any one locality cannot always be taken as an indication of quality but in general it may be accepted that large bunches of fruit are usually of good quality and keep better during storage than small bunches; the appearance on ripening is also better. In Australia it has been found that poor quality fruit requires more careful treatment in the ripening-rooms than good fruit. It has been shown, for example, that poor fruit is more adversely affected by high temperatures than is good material. In chilling experiments conducted in Trinidad indications were obtained that large, vigorous bunches were less susceptible to low temperature injury than poorer bunches. In Queensland it has been found that Cavendish bananas grown on a shale or clay soil deteriorated much more quickly and were generally inferior to fruit grown on good soils of volcanic origin.

WASTAGE IN BANANA SHIPMENTS

Wastage, sometimes very considerable, is a feature of all banana shipments. From the time of cutting bunches are subject to the inroads of a large number of fungal organisms. Some of these have already been established during development, and remain as latent infections until the fruit is entering on the final phase of maturation. A large number of the fruit-rotting fungi, however, gain access through the various cuts and bruises inseparable from reaping and transport operations. These develop slowly during the cold-storage transport period and rapidly when the fruit is taken to the higher temperatures prevailing in ripening rooms. Delay in applying refrigeration to harvested bunches greatly accelerates the onset and intensity of wastage. Hence the recommendation that the time between reaping of bunches and cooling to 53° F. be curtailed to the minimum. The several aspects of disease, attributable to a varied and extensive fungal flora, have been classified as follows: main-stalk rot; cushion infections; finger-stalk rot; and finger diseases.

In the matter of fungal wastage the Cavendish and Lacatan (Giant Fig) varieties are considerably more susceptible than the Gros Michel. A seasonal drift may sometimes be observed in the incidence of rotting, as in Brazilian Cavendish consignments. Other factors, including those of soil and climate, also predispose fruit to a greater or less susceptibility to the several pathogens. Manurial treatment may also be important. Thus when the Cavendish variety is grown on poor soils with the help of fertilizers in Trinidad, the tendency of bunches to suffer from mechanical injury and fungal penetration is greatly accentuated. Cargoes which have been chilled *en route* show increased fungal wastage during subsequent ripening.

TRANSPORT BY LAND

On arriving at the port of destination, the fruit is discharged by means of mechanical conveyors, and is placed in specially constructed fruit cars or

waggons for distribution. Where refrigeration is necessary, as in the United States, the waggons are maintained at a temperature of 54° F. Attention has already been directed to the special conditions of overland transport involved in Queensland banana industry.

RIPENING

On being discharged from the holds, the bunches, still mostly green, have next to be ripened. This is done in special ripening-rooms usually at a temperature of 66° to 68° F. or less according to the demand for ripe fruit. Each bunch is suspended with the lower or distal end uppermost by a rope attached to the ceiling. Fruit which is ripe or nearly ripe on being discharged from the holds is retailed immediately. In well-equipped modern ripening-rooms the installation includes apparatus for the control of temperature and humidity.

At the time of reaping the storage material in the green banana is almost entirely starch, approximately 30 per cent. by weight being present, as against only 0·7 to 0·8 of sugars. Ripening is characterised by many changes, including the yellowing of the skin, the transformation of all or practically all the starch into soluble sugar, the oxidation of tannins, the softening of the fruit, the transformation of insoluble pectose (protopectin) into soluble pectin, and the production and liberation of various volatile substances which give the ripe fruit its characteristic aroma and flavour. Later, when the fruit is tending towards the over-ripe condition, the skin become covered with a dark brown mottling and alcohol begins to accumulate in the pulp. At this stage the fruit is usually exploited by various fungal pathogens. The rate at which these changes take place depends chiefly on the maturity of the fruit and the temperature of the ripening-room but other factors are also involved.

Ripening Temperatures.—Reynolds cites the following temperatures for fruit received in the United States of America :—

56° F.	..	..	holding ripe fruit
58° F.	..	..	holding green bananas
62° to 66° F.	..	..	normal ripening
68° F.	..	..	forced or fast ripening
72° F.	..	..	danger of cooking

These values refer, of course, to the heavier grades of Gros Michel fruit. For standard $\frac{3}{4}$-full bunches received in Britain, normal ripening temperatures range from 60° to 70° F., according to circumstances, a starting temperature of 68° F. being commonly used.

In Australia, green Cavendish fruit may be stored, during the summer months, in ripening-rooms for three days at temperatures of 53° to 58° F. provided the atmosphere is quite free from ethylene ; partially ripe, cased bananas may be held for three days at 55° to 60° F. during which time they colour slowly but remain in good condition for some time after removal,

Uncrated fingers or fruit in the bunch should not be cooled below 62° F. During the winter months (average air temperature 50° to 60° F.) green bananas may be stored for periods up to seven days outside the ripening-rooms in any dry place, provided no traces of coal-gas are present.

As a rule, during the earlier stages, a high R.H. (85 per cent.) is maintained in the ripening-rooms, but once the fruit is "sprung," *i.e.*, showing a definite yellowing and signs of active ripening, the R.H. is reduced to 70 to 75 per cent. to harden the fruit and to curtail the activities of superficial fungi. If the humidity is too low, evaporation from the fruit tends to be excessive and as a result the peel develops a poor colour and a somewhat withered or desiccated appearance. The quality of the ripe fruit may also suffer. During the hardening period at a lower R.H. the temperature may also be reduced. Bananas ripened at a high temperature—temperatures of 72° to 85° F. are sometimes used to force ripening—are of poorer flavour and tend to deteriorate rapidly. Where high temperatures are used the period of exposure should be very brief, 12 hours or less. High relative humidities (above 85 per cent.) are also to be avoided, particularly where cased fruit is being ripened. The following table, based on crated fruit (Australian) held in ripening rooms at 68° F. shows the effect of high humidity on the temperature of cased bananas.

AUSTRALIAN CAVENDISH VARIETY (CRATED)

(AFTER YOUNG, BAGSTER, HICKS AND HUELIN)

Temperature of room	Humidity %	Case temperature after 2½ days
68°F.	80	76·0°F.
68°F.	85	77·2°F.
68°F.	90	78·5°F.

These differences are attributable to the fact that the increased humidity causes less transpiration from the fruit with a reduction in the cooling effect due to evaporation.

The Cavendish variety suffers from exposure to high temperatures in the ripening-room, yielding an ultra-soft fruit of unpleasant flavour, odour and colour (pale greenish yellow) generally described by the trade as *boiled*. The ripening of this variety in Australia has been made the subject of intensive research. For practical purposes the following stages of ripeness have been described :—

(i) hard green; (ii) sprung, *i.e.*, when the fruit still appears hard and green but has gained a definite flexibility; (iii) colour shows, *i.e.*, when the first tinges of yellow appear; (iv) half colour, *i.e.*, when

the green and yellow both appear ; (v) green tip, *i.e.*, when the fruit is full yellow except at the extreme lower end ; sometimes there is no definite "green tip" stage, the fruit colouring evenly to yellow ; (vi) full colour ; there is sometimes some persistence of green at the flower end, but a fairly definite "full colour" stage can always be recognized ; (vii) full ripe, *i.e.*, clear yellow with signs of dark marking (flecking) ; (viii) flecked, *i.e.*, markings well developed ; (ix) deteriorating, *i.e.*, when pulp begins to soften.

In general, a temperature of 68° F. has been found suitable for the ripening of the Cavendish variety as grown under Australian conditions. But because of difference in the quality of fruit from different areas, production under summer and winter conditions, &c., a considerable elaboration of the ripening technique, involving the use of ethylene or unburnt coal gas as an accelerant, has been found necessary. For a full account the reader is referred to the original memoir of Young and his colleagues.

Accelerated Ripening.—It has been found that traces of ethylene, one of the ingredients of coal-gas, exercise an accelerating action on the ripening of various fruits, including the banana. It has also been shown that various fruits give off volatile substances, now known to include ethylene. Hence arises the action of ripening or ripe fruit in promoting the maturation of green fruits in close proximity and the need for eliminating volatiles from the atmosphere of storage rooms or holds in which fruit has to be maintained in the green condition. When quick ripening is required, however, ethylene or unburnt coal-gas, in very small concentrations, may be used to advantage on a commercial scale. Indeed, it has been found impossible to ripen Queensland Cavendish varieties satisfactorily unless traces of accelerating substances are present in the atmosphere of ripening-rooms.

CORRESPONDENCE

Maliboda,
Deraniyagala,
Ceylon,
6th May, 1937.

The Editor,
The Tropical Agriculturist,
Peradeniya

Dear Sir,

I enclose an article which I hope that you may see your way to publish in *The Tropical Agriculturist.*

The plot selected was of average slope and the soil neither better nor worse than is met anywhere in this district ; the experiment is justified if only by proving that there is no need for the soil to deteriorate in the way the average *chena* soil does after one crop. I am certain that the soil is actually better than when I started, and is capable of continuing to grow crops if the rotation is continued, although in a scientist's opinion it may be too early to say this with any certainty, this is my opinion.

I am,
Yours faithfully,
R. Neville Rolfe

ROTATION OF CHENA CROPS IN THE WET ZONE

Some three years ago an idea which had been simmering for some time became a possibility, due to the lifting of the depression, and I laid out a *chena* in three parts.

The acreage was intended to be large enough to support a family, and yet not too large for members of the family to take up work outside when it offered. I was under no illusion that *chena* cultivation, however intelligently worked, can compare in returns with regular employment at estate rates.

I thought that two acres would be sufficient, but from what I have since learned, think that the minimum should be three acres of field. If it were for a colony, a further two acres would be required for the house and permanent cultivation.

This article only deals with the vicissitudes of the *chena* crops. You, who will have noticed how the villager uses the ground, must remark on its wastefulness of both top soil and labour. The land has each time to be felled, burned, and fenced. Crops can only be planted after the cultivator has burned, and not when he wishes.

To take the cost of fencing alone, if any one of us had to pay labour to build such a fence, it would cost far more than we could possibly hope to get back in one year's cultivation, and yet the fence is only there for a year or

possibly two. I admit that experience has taught me that the cultivators are not such fools as they appear to be in building as they do, but this only emphasises my point that a permanent fence is a first essential for a rotation. Gliricidia makes a good fence, but more is wanted, and I suggest a mixture of mulberry and gliricidia, with a trench dug later as time permits.

The preservation of the soil can best be done by platform terraces. The criticism will at once be made as to how the "non-capitalist" can do this; it must, of course, be a matter of time where labour cannot be paid for, but there is no need in the first case to cut large platforms. In fact this is to be deprecated as this will bring up too much of the subsoil on which crops will not readily grow. I am only entering now upon my third year, but hope that at the end of five years I shall be able to run a plough over much of the land; I have in mind a machine with a wheel embodying plough, harrow, and weeder.

It must be remembered when reading these notes that I am a "full-time" planter, and that I have not been able to devote the time I should like to "the chena," and that my assistants have not the enthusiasm for the success of the experiment that I have. I must record my thanks for all the help I have received from the staff at Peradeniya, and from the Agricultural Instructor at Ruanwella.

The crops in the three fields should be (1) grain, (2) legume, (3) a root.

(1) In the first year was "hill paddy." We, most of us, know it as a luxury, and my experience is that that is exactly what it is.

(*b*) *Amu* I rule out, as in my opinion this is only an indifferent food and a lazy man's crop, and my experiment is not for lazy men.

(*c*) *Kurakkan.* This crop is not at all certain, in fact I should say that NO grain crop is at all certain in the wet zone.

I am still experimenting with barley and sorghum, and from what I can see these or one of these is going to be a very helpful crop.

(2) Legume. My original crop was a mixture of *me-charal* (horse-pea), *tatapiru*, and dwarf beans (bought from the Kandy market by the peck); interplanted with these were cucumbers, *timbura* and other vegetables. The record of this crop was not satisfactory, but from my own judgment there was sufficient for a family for a year.

This crop was followed by a grain crop of hill paddy, but this was a failure; I was away at the time it was harvested but I gather that the failure was due to "fly."

(3) The original root crop was manioca, and this was thoroughly satisfactory; I was informed that the weight harvested was 22 cwt., but in my opinion there was far more than this. This was followed by a crop of peas, and again by sweet potatoes, of which ten varieties were given me by "Peradeniya." These grew well, and although these ten varieties have got mixed, they are going out again in a field cropped with manioca last year, but which

has lain fallow for a few months. I do think it important that the land should lie fallow for a few months, and this will best be effected by having a fourth field.

It is a curious thing that the sweet potato is not appreciated by the villagers round here (though they admit that some of the Peradeniya varieties are better than what they have grown, but this may again be politeness); they say "I would rather have one pound of manioca than 10 lb. of *batala*" and yet will pay 8 or 10 cents for "English potatoes." I admit that I do not understand their prejudice for I frankly prefer a good sweet potato to the imported potato. Some of the varieties rank with the King Edward or the mealy potatoes one gets in the shops in England at the end of the year.

It must be realised that the land may lie fallow for some months (this I did not sufficiently appreciate) and that, owing to the seasons, crops do not follow each other directly. This is all to the good as the weeds and grasses can all be turned into the soil. Arrangements have to be made for a nursery for the *batala*. The manioca sticks stacked in a corner of the field appear to keep green for some time, and are perhaps none the worse for it.

I am to try a new pea (*thorum*), but have difficulty in getting the seed. *Thorum* is new to this side of the country, but perhaps it has all been tried in the dim past and found wanting.

I cannot conclude without mentioning pests; perhaps no farmer is without them, but I think Ceylon must have pride of place.

Birds are said to be a mixed blessing, and the ingenious arrangements for scaring them are worthy of Heath Robinson, but if you have to pay the labour at union rates it is costly, too costly to be worth while, to grow grain.

Pig, I feel, one should be able to discourage, but never tell me that a pig is a fool.

The *mouse deer*, whom I would call a fool, blunders in and does his bit (of damage).

Bandicoots and *rats* deserve a special page in the anathema, and lastly and perhaps not least is *homo sapiens*; some people, otherwise honest, seem to look upon *chena* crops as fair game, in the same way, perhaps, as an apple orchard.

One thing must be kept in mind all the time. Villagers are very prone to plant a permanent crop on their clearings. If this were properly done there might be something to be said for it, but they so often just throw a handful of arecanuts out, and the clearing becomes a "garden" from which little or nothing is reaped, but which is useless for annual crops.

In my "ideal small holding" of five acres, the permanent crops are there, but my fields are kept as such.

The experiment is incomplete, my records are admittedly not altogether what I should wish, but if this article prompts others with more leisure to duplicate the effort on their own lines, benefitting by my mistakes, I believe that a step forward in forming a contented peasantry might be achieved.

THE COCONUT INDUSTRY IN NEW GUINEA

No. 2 of Volume 2 of "The New Guinea Agricultural Gazette," October, 1936, consists of "A Survey of the Coconut Industry in the Mandated Territory of New Guinea" by H. E. P. Dwyer, Economic Botanist. The seventy-two pages of this survey contain much of interest to Ceylon producers and we therefore publish below an abstract by Dr. R. Child, Director of Research, Coconut Research Scheme, Ceylon, of some of the topics discussed, with comments between brackets.

COPRA is the most important agricultural export of New Guinea, and indeed, until gold production developed in recent years, it was outstandingly the principal product of the territory. The annual exports of copra exceed 60,000 tons, an increase of about 60 per cent. since 1924. This represents some 40 per cent. of the total exports of the British South Sea Islands, Fiji and the Solomon Islands ranking respectively as the second and third largest exporters in this zone. The South Sea Islands in 1929 supplied 42 per cent. of the total imports into the United Kingdom, and 50 per cent. of the imports from British Empire sources.

ACREAGE OF COCONUTS IN NEW GUINEA

The bulk of the world production of coconuts is in the hands of small holders ; this is not, however, true of New Guinea, where the larger European owned estates form the bulk of the planted areas. In 1914, the total planted area was estimated at 76,847 acres (23,572 acres in bearing); by December, 1918, this had increased to 133,960 (44,169 acres in bearing) and in 1935 the estimate was 218,779 acres (170,825 acres in bearing). The average yield in copra per bearing acre, from planters' returns and from export figures, appear to be about 1937 lb. (a little over 3½ candies), which compares very favourably with most of the best Ceylon estates.

The coconut areas in New Guinea are largely confined to the sea-coast, mostly on loose soils derived from coral rock. The soils next in importance to coral are those of volcanic origin.

Land is stated to be cheap and there are still plenty of available areas suitable for coconuts. The indications being that copra will stabilise at paying

prices, and the future of copra being at least as certain as that of other oil-seeds, some extension of planting may be expected.

NATIVE COCONUT CULTIVATION AND COPRA PRODUCTION

Coconuts enter largely into the internal economy of the Island as an article of trade and barter and form a large part of the staple diet. Coconuts from small holdings are often cured on the large plantations and the copra is sold as plantation copra. It is not possible to say at present what proportion of the copra exported is of such origin, and statistics are lacking of the native acreage ; 25,000 acres is the rough estimate given. Further survey is being made to obtain statistics and an article on the subject is promised for a later date.

HISTORY OF THE COCONUT INDUSTRY IN NEW GUINEA

The history of the development of the copra industry is traced from the beginning of German colonization to the present time. In 1883 a plantation was laid out at Ralun, on Blanche Bay, and the first plantation on the main land was commenced at Finschhafen in 1885.

The total capitalisation of the plantation copra industry is estimated at £5,000,000.

FLUCTUATIONS IN EXPORTS OF COPRA

A table is given of exports, reproduced here, for different years 1884–1935. It will be apparent that there was a steady increase up to 1927–28 more or less parallel with the increase of acreage in bearing. Since then exports have been round about 60,000 tons annually and show a slight decline, although more acreage must still be coming into bearing. Unfavourable climatic conditions are said to have contributed to this slight decline. More important has been the necessity for economy during the slump and the consequent reduction of cultivation ; in many areas there is decided evidence of soil exhaustion. It is also suggested that the older planted areas are beyond their stage of maximum production and their output consequently decreasing. [Since the bearing acreage in 1914 was estimated at 23,572 acres and now at 170,825 acres, this cannot be yet as serious a problem as it is in Ceylon, where many estates first planted in the 1860's to the 1880's have done little replanting.

To make a further comparison, Ceylon's exports in 1936 amounted to only 73% of the 1927–1936 average, and whilst drought conditions in 1934 contributed to this, the most important factors are the cessation or reduction of cultivation and manuring during the slump, and the decline of old areas].

Year	Exports Tons	Value Exports £	Average price per ton f.o.b. £	s	d	Percentage value over Total Exports
1884	1,300	—	—	—	—	—
1898	2,500	—	—	—	—	—
1904	4,400	—	—	—	—	—
1909	8,518	106,326	12	9	6	—
1910	9,099	148,758	16	7	0	—
1911	9,397	163,090	17	6	11	—
1912	11,428	198,338	17	7	1	—
1913	14,299	302,186	21	11	8	—
1914	—	—	—	—	—	—
1915–16	11,062	161,119	14	11	3	—
1916–17	18,582	267,277	14	7	8	—
1917–18	19,708	369,837	18	15	4	91
1918–19	14,886	244,314	16	8	3	90
1919–20	22,708	745,057	32	16	3	88
1920–21	23,735	644,045	27	0	2	96
1921–22	25,894	474,110	18	6	2	95
1922–23	34,648	619,715	18	19	8	98
1923–24	34,974	686,519	19	12	2	98
1924–25	39,151	815,938	20	19	10	95
1925–26	45,806	1,016,930	22	3	6	92
1926–27	47,613	849,852	18	4	0	79
1927–28	65,285	1,176,040	18	2	6	80
1928–29	60,435	933,769	15	9	0	81
1929–30	63,832	864,358	13	10	0	87
1930–31	62,303	716,543	11	10	0	78
1931–32	59,452	618,298	10	8	0	56
1932–33	59,040	543,906	9	4	3	34
1933–34	62,270	283,329	4	11	0	16
1934–35	56,251	361,413	6	8	6	15

DESICCATED COCONUT PRODUCTION

The production of desiccated coconut is now a small but established industry in New Guinea, providing the bulk of the requirements of the Australian market. Any great extension of the annual production, which has increased from 26 tons in 1928-29 to 1,611 tons in 1934-35, cannot be anticipated unless payable markets other than Australia are available.

OIL MILLING

It is suggested that oil milling might be started in New Guinea, with possible markets in Canada, Australia and the East.

QUALITY OF NEW GUINEA COPRA

South Sea Island copra is recognized in the trade as being inferior in comparison with that of other countries. This until 1929 included New Guinea copra. The Rabaul plantation grade now, however, receives a premium.

A great diversity of copra driers is used leading to great variation in the type of copra produced. Many are of the hot air type, with natural draught. The Ceylon type of drier is employed on some plantations and its use may spread, as it has been recommended by the Department of Agriculture, who also state that there is a definite need for some form of standardization of the product, a standard drier being evolved, cheap to erect and maintain and capable of yielding a superior copra.

It is pointed out that owing to the length of the sea voyage to England, South Sea copra is liable to more deterioration and its initial preparation must therefore be good.

COPRA INSPECTION

New Guinea copra is submitted to a compulsory inspection before export which is stated to be more stringent than that carried out in any other part of the world. The recognised grades for the London market are "Hot Air dried," "Plantation Sun dried," and "Common or Smoke dried." A fourth grade "Trade Copra" goes to Marseilles in considerable quantities. The comparative London prices in May, 1936 were :—

Hot Air	£13–15–0
Sun dried	£13– 0–0
Smoke	£12–12–6

Further reference is made below to other legislation in New Guinea affecting coconut products. Attention is here drawn to the fact that the premium now obtained over South Sea copra is largely attributed to the effect of the compulsory inspection. There has also been an increase in the proportion of Hot Air dried produce as the following table shows:—

	Hot Air Per cent.	Sun Pltn. Per cent.	Sun Trade Per cent.	Smoke Per cent.
1931–32 ..	46	11	4	38
1935 ..	75	8	4	13

COST OF PRODUCTION

In 1922–4 the cost of production per ton of copra was estimated at £9. Recent estimates are quoted from £7–10–0 to £8–0–0, though it is stated by planters that the cost should not exceed £5 per ton delivered at Rabaul, and figures as low as £3, £3–10–0 were recorded for some plantations (not including freight to Rabaul).

[£5 per ton is approximately equivalent to Rs. 18·75 per candy, which is not far from the average cost of production on Company estates in Ceylon. Cases of estates in the North-Western Province of Ceylon producing at Rs. 10·00 per candy or even less are known].

LEGISLATION

The Copra Inspection Ordinance of 1928 has already been referred to. Other legislation affecting coconut products includes the "Plantation Diseases and Pests Ordinance 1934," which provides regulations for inspection of plants, the prevention of the spread of fungus and insect pests, etc. and "The Customs Tariff Ordinance 1933–36," under which coconut products pay excise duty according to a sliding scale based on the market price. In 1934 New Guinea copra under this scale was practically free from export duty.

An interesting point is that under the last ordinance the use of second hand copra bags is prohibited.

Native Labour Ordinances and Regulations also affect the industry in all matters pertaining to labour.

NEED FOR RESEARCH

The article concludes with by expressing the need for an organized scheme of research dealing with copra and coconuts in the Territory, such work to include chemical investigation of soils, the growing palm and the copra produced, as well as plant breeding, cultural and manurial trials. There is also need for more information on fungus and insect pests, whilst marketing problems demand attention.

[It is a source of some satisfaction to know that active investigations on all of these subjects is going on in Ceylon, where the Research Scheme is well established].

AWARD OF THE MAYNARD GANGA RAM PRIZE

IN 1925 the late Sir Ganga Ram, Kt., C.I.E., M.V.O., R.B., Lahore, with that generosity for which he was so well known, handed over to the Punjab Government a sum of Rs. 25,000 for the endowment of a prize of the value of Rs. 3,000 to be called the Maynard Ganga Ram Prize and to be awarded every three years, for a discovery, or an invention, or a new practical method which will tend to increase agricultural production in the Punjab on a paying basis. The competition is open to all throughout the world. Government servants are also eligible to compete for it.

The first award which was due in 1929 was made in 1931 to Dr. Barber, late Imperial Sugar Expert, for his fundamental discoveries which resulted in the production of Coimbatore Sugar-cane. During the last five years no further awards have been made owing to lack of suitable entries concerning which sufficient information was available. The 1932 award has now been made by the Managing Body to Mr. T. A. Miller Brownlie, late Agricultural Engineer to Government, Punjab, for his invention of a slip strainer suitable for water augmentation supplies derived from bores sunk in open wells. This strainer has the particular merit that it is not affected by alkaline sub-soil water—a defect from which many of the earlier metal strainers suffer. The new strainer is also cheaper than the former types in use. It has been tested now for several years in a large number of wells and has given excellent results. By its use owners of well irrigated lands can increase the output of water from their wells. Consequently they can grow a larger area of crops on wells so equipped and a greater range of better paying crops.

Meantime the 1935 award fell due. The Managing Body has awarded it to R. S. L. Jai Chand Luthra, I.A.S., Professor of Botany, Punjab Agricultural College, Lyallpur, for his new method of treating wheat seed in order to free it from a fungal disease called Loose Smut. This disease is present in most parts of the province and causes considerable loss to cultivators. The old method of treatment involved the use of a thermometer and required skill and accuracy in raising water to a temperature which was sufficient to kill the spores of the disease inside the wheat grain and yet not damage the germinating power of the grain. Consequently, the method was unsafe in the hands of unskilled and illiterate people. By R. S. L. Jai Chand Luthra's method the use of a thermometer is rendered unnecessary. The wheat seed to be treated is merely soaked in water at ordinary temperature for four hours during the morning of a day in summer. Thereafter the soaked grain is spread

in the sunshine till it is thoroughly dried. Experience has shown that this treatment is effective in controlling the disease without damaging the germinating power of the seed. It can be carried out safely by any illiterate worker.

Entries for the next award should reach the Director of Agriculture, Punjab, Lahore, on or before the 31st December, 1938.

BULLETINS

The following Bulletins have been recently published by the Department of Agriculture, and are available at 25 cents per copy from the Propaganda Office, Peradeniya :—

No. 89.—Soil Erosion

No. 90.—The cultivation of fruits in Ceylon, with cultural details.

Department of Agriculture,
Peradeniya, May 15th, 1937.

REVIEWS

A Handbook of Statistics for use in Plant Breeding and Agricultural Problems.—By F. J. F. Shaw, C.I.E., D.Sc., A.R.C.S., F.L.S. Published by the Imperial Council of Agricultural Research, Delhi, India. Rs. 4–6.

THE increasing use of statistical methods in agricultural research during recent years has created a need for some kind of textbook, something not quite so coldly analytical as the textbook of statistics (from which however it must derive its substance) but with a semblance of life drawn from the agriculture that it seeks to help.

A number of such books has appeared recently, among them one which may be said to be of local application, for a problem seems to be more easy of understanding when it is expressed in terms with which we are familiar. The late Dr. Shaw, whose sudden death last year has robbed India of one of her foremost research workers, had compiled a handbook of statistical methods, based on part of a course in plant breeding given at Pusa. The course was for post-graduate students, and the book assumes a corresponding standard of knowledge in its readers ; by which statement, we mean that it "is not intended as a treatise in mathematical statistics" (author's preface), and will be of little use to the student who has no knowledge of the subject. It does bring together, however, those developments in statistical analysis that are of use to the agricultural worker. It gives a full list of the various ways in which field trials may be arranged (including even the chessboard method, which is surely little used now) with appropriate examples of each ; it touches lightly, perhaps too lightly, on complex and serial experiments, and it ends with a chapter on the use of co-variance for the correction of soil heterogeneity. It gives a full bibliography, and gives it chapter by chapter, so that difficult points may be elucidated as the reading proceeds.

It is almost inevitable that in a book so full of figures, there should be some errors ; they are very few, however, and will no doubt be corrected. It is not quite clear why, in the experiment recorded on pp. 99-106, the experimental area should be bordered at either end by a plot of the variety C ; if any particular variety is to be used, would it not best be A, which is being used as a control ?

For a book so informative, the price is very low, and should ensure the wide distribution that the work deserves.—J. C. Haigh.

EFFICIENT PRODUCTION OF CACAO*

I. The Cacao Industry of Trinidad, Some Economic Aspects, Series II.—A Financial Survey of Estates during the Seven Years 1923-24 to 1929-30. Pp. 30+2 Appendices+9 Tables+2 Maps+43 Figs. (Reprinted from "*Tropical Agriculture,*" Vols. XIII, 11 and 12 and XIV, 1-5).—Price 3·00, post free.

II. The Cacao Industry of Trinidad, Some Economic Aspects, Series III.—An Examination of the Effects of Soil Types and Age on Yield. Pp. 50+4 Appendices+25 Maps+46 Figs. Series IV. Recommendations for Improving the Efficiency of Estates. Pp. 22+2 Appendices.—Price 4*s.* 6*d.*, post free.

THE researches of Mr. C. Y. Shephard, Carnegie Professor of Economics at the Imperial College of Tropical Agriculture, into the economic aspects of the Trinidad cacao industry are now available in the form of two publications which should make a wide appeal to those interested in this plantation crop. In the first of these publications the records of a large number of estates are submitted and have been examined with the object of ascertaining the profitable and unprofitable factors associated with cacao production. It not only includes a careful analysis of every item of expenditure incurred on estates but also draws striking comparisons between the figures obtained on some of the "best" and "worst" estates in Trinidad. From these data a planter or owner of cacao properties should be in a position to judge whether his results compare favourably or not with those of others. Generally speaking, the most profitable estates obtained high yields, spent less than the average on cultivation, were about 300 acres in size, consist of youthful fields, purchased no manures and in most cases specialised almost entirely on the production of cacao. Professor Shephard, however, reveals the weakness of the orthodox economic survey by pointing out that the relationship between some of these factors and costs of production is not that of cause and effect, and the analyses are therefore dangerous bases for recommendations. He proceeds therefore in the second publication to develop a comprehensive technique of his own in which the findings of scientific specialists, the experiences of individual planters and the results of orthodox economic analyses are integrated so that the fundamental causes of profit and loss in the cacao industry are seen in true economic perspective. By this new method of approach the author renders a signal service to producers of cacao, whether situated in the West Indies or West Africa and makes an important contribution to methods of agricultural economic research. The technique is applicable, with suitable modifications, to many other tropical products. In the concluding portions of this second publication recommendations are made for improving the efficiency of cacao estates and much useful information is given on the more modern aspects of cacao production.

Both publications may be obtained on application to the Editor, "Tropical Agriculture," Imperial College of Tropical Agriculture, Trinidad, B.W.I.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED MAY, 1937

Province, &c.	Disease	No. of Cases up to date since Jan. 1st, 1937	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	111	41	66	..	45	..
	Anthrax	..	..	..	..	..	..
	Rabies	7	1	..	..	..	7
Colombo Municipality	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	491	61	460	7	24	..
	Anthrax	10	3	..	10	..	..
	Rabies	10	..	..	10	..	..
	Trypanosomiasis	1*	1	..	1	..	..
	Blackquarter	1	..	..	1		
Cattle Quarantine Station	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	1	..	1	..	..	..
	Anthrax	23	7	..	23	..	..
Central	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	68	..	67	1	..	..
	Anthrax	..	..	..	..	..	..
	Piroplasmosis	1	..	..	1	..	..
Southern	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	170	170	118	..	52	..
	Anthrax	..	..	..	..	..	..
Northern	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	1414	321	991	37	386	..
	Anthrax	..	..	..	..	..	..
Eastern	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	61	..	61	..	..	..
	Anthrax	..	..	..	..	..	..
North-Western	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	2	..	2	..	..	..
	Rabies	3	..	..	1	..	2
	Piroplasmosis	1	1	..	..	1	..
North-Central	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	60	21	35	..	25	..
	Anthrax	..	..	..	..	..	..
Uva	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	131	..	125	6	..	..
	Anthrax	..	..	..	..	..	..
	Rabies	3	1	..	..	..	3
Sabaragamuwa	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	109	109	..	9	100	..
	Anthrax	..	..	..	..	..	..
	Piroplasmosis	4	..	3	1	..	..
	Rabies	2	2	..	..	..	2

* Detected at slaughter house

Department of Agriculture,
Peradeniya, 18th June, 1937

M. WIJAYANAYAKA,
for Deputy Director of Agriculture (Animal Husbandry) & Government Veterinary Surgeon

METEOROLOGICAL REPORT—MAY, 1937

Station	Temperature: Mean Maximum	Temperature: Difference from Average	Temperature: Mean Minimum	Temperature: Difference from Average	Humidity: Day	Humidity: Night (from Minimum)	Amount of Cloud	Rainfall: Amount	Rainfall: No. of Rainy Days	Rainfall: Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	86·8	+0·3	77·3	+0·2	78	91	8·0	18·63	26	+ 3·65
Puttalam ..	88·6	+0·9	79·0	+0·8	75	89	5·2	0·93	6	− 2·81
Mannar ..	90·1	+0·3	82·4	+2·1	72	79	3·9	0	0	− 1·90
Jaffna ..	88·2	+0·5	82·7	+1·5	78	83	5·1	0	0	− 1·65
Trincomalee ..	93·5	+2·4	79·2	+0·9	60	78	4·6	1·16	3	− 2·29
Batticaloa ..	90·1	+0·1	78·0	+0·6	70	89	3·7	2·03	4	+ 0·14
Hambantota ..	88·4	+2·4	78·0	+1·2	78	89	4·2	1·98	12	− 1·45
Galle ..	85·0	+0·5	78·0	+0·7	82	86	6·5	18·92	24	+ 6·45
Ratnapura ..	86·8	−1·4	74·5	−0·1	80	95	7·1	31·89	25	+11·82
Anuradhapura ..	92·8	+3·1	76·5	+0·5	68	93	5·8	0·07	3	− 3·06
Kurunegala ..	89·2	+0·6	75·7	+0·3	74	91	6·4	8·78	13	+ 2·10
Kandy ..	87·3	+1·2	71·0	+0·2	70	92	5·4	4·06	15	− 1·93
Badulla ..	86·5	+1·7	66·6	+0·2	66	92	4·2	3·13	10	− 1·55
Diyatalawa ..	76·8	−1·5	62·1	+0·2	70	86	4·8	3·44	8	− 2·42
Hakgala ..	74·4	+2·1	58·5	+1·3	74	86	4·3	2·71	13	− 5·25
Nuwara Eliya ..	71·0	+1·0	53·9	+1·0	77	94	8·1	4·40	19	− 2·48

The rainfall of May was generally above normal in the south-west of Ceylon, and below normal elsewhere. Excess was most marked in the low-country districts to the south-west of the main mountain masses. The greatest excess reported was 33·17 inches, at Marambekande Estate, and excesses of more than 20 inches were also reported from Yatiyantota, Hanwella Estate, Labugama, Ruwanwella, Carney, Digalla. In the Jaffna Peninsula and the north-west of Ceylon, most stations reported no rain during May, while in other districts north of the Puttalam-Batticaloa line, very few stations reported monthly totals of as much as 2 inches.

There were 118 daily falls of at least 5 inches reported during the month. Of these more than half were on the 26th. Nearly all the remainder were on the 5th, 25th or during the four days 14th-17th. The highest fall reported from the stations reporting regularly to the Observatory was 14·75 inches at Maghalkande (Vincit Estate), on the 26th, but a fall of 23 inches was reported as having fallen not far from Maliboda Estate. Falls over 10 inches were also reported from Ambepussa, Carney, Dabar, Marambekanda, Pindeniya, Yatiyantota, Ruwanwella, Kitulgala, Kokkawita, Etnawala, Kanangama, Poramadela, Ingoya and Vincit, nearly all on the 26th.

For the first week of May there was rain, generally moderate, and mainly confined to the south-west of Ceylon. The rain was fairly heavy, however, on the 4th and 5th, particularly on the latter day. From the 7th to the 13th practically no rain was reported anywhere. The rain then increased, but was still mainly confined to the south-west of Ceylon. About the 19th the rain fell off, but increased again on the 21st. There was heavy rain in the south-west of the Island on the 25th, and further exceptionally heavy widespread rain in that part of the Island on the 26th, the latter rain being mainly responsible for a major flood in the Kelani Ganga, which reached its peak on the 29th-30th. The intensity of the rain then decreased, but it was still moderately heavy till just before the end of the month.

The barometric gradient remained consistently south-westerly during the month, and winds were generally westerly, while wind-strength was above normal. The mean barometric pressure was above normal at nearly all stations, but the mean gradient showed no appreciable deviation from the normal. Temperatures were generally above normal. Humidities showed, in general, no marked deviations from normal, while cloud was, on the whole, below normal, particularly up-country.

H. JAMESON,

Superintendent, Observatory.